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FLIGHT

AIRCRAFT, SPACECRAFT, MISSILES

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B.O.A.C. Gets Tough

FOR nearly 15 years Britain has scrupulously upheld the principles of international civil aviation law and order which we and the Americans did so much to establish at Chicago in 1944 and at Bermuda in 1946. And we have always stood fast by the International Air Transport Association, a body which (with an Englishman in its highest office) has striven to keep politics to a minimum in the world's most nationalistic industry.

Suddenly, in an action that had a whiff of jingoism about it, one of Britain's two national airlines badly rocks the I.A.T.A. boat. Earlier this month at Honolulu, where I.A.T.A. met to sort out next year's fares, B.O.A.C. was no longer the agreeable club member it had been in the past. This was a different B.O.A.C., an airline which had rattled sabres in public before the meeting (a deadly I.A.T.A. sin), and which was completely uncompromising in its demands. Unless it got what it wanted, namely economy class fares on its routes to Africa and to the Far East and Australia, it would operate such services to the British colonial cabotage points on these routes.

The meeting broke up, not for the first time in disagreement, but for the first time in the knowledge that there was to be no further negotiation. Some airlines say that economic anarchy will prevail as from April 1 next. Will it? The exercising of B.O.A.C.'s cabotage fare-fixing rights may not divert traffic flows enough to upset foreign airlines. And though these carriers may find B.O.A.C.'s high costs (see page 479) hard to reconcile with their low-fare demands, there is no disputing the fact that here is an airline which, instead of just talking about low fares, is *doing* something to get them implemented.

New Exertions

PETER PAN managed to get airborne by thinking lovely, wonderful thoughts. Others have striven for the same effect by flexing their muscles—but have succeeded only in vexing their minds. Their efforts to levitate themselves have brought forth only levity from others.

In his paper *Man-Powered Flight* (abstracted in *Flight* for November 21, 1958) Mr. Beverley Shenstone remarked that so many irresponsible people had played with the idea that it was becoming difficult to take it seriously. But he had something else to say—that though man-powered flight was often thought to be far from reality, it had already been *nearly* accomplished. The italics are ours, because he went on to say that a German man-powered aircraft made at least four flights of over two hundred yards during 1936.

Thus, for almost a quarter of a century—while man has been taming supersonics, and even space itself—this age-old challenge has remained. Now men are trying once again to fly by their own exertions. The Hartman ornithopter, described in this issue, is only one manifestation of this human phenomenon. In recent months we have noted several projects of the sort, and today—October 30, 1959—the inaugural meeting of the Man-Powered Aircraft Group of the Royal Aeronautical Society is taking place.

Mr. Shenstone remarked that there is a belief that if man could fly he would have done so long ago. His own view was that this attitude was nonsense, and that it would be better to say that if something hadn't been done it was high time to do it. At last, it seems, that time may really be at hand.

***JUNIOR ROTARIANS:** Far left, the first Hiller XROE-1 Rotorcycle built by Saunders-Roe Ltd. It was flown on October 19 by Phil Johnston of Hiller. The second machine is the new Bensen B-9 "Little Zipster," which will sell complete for about $7,000. Alternatively, it will be offered in kit form, at prices from $980 to $4,500, depending on the amount of factory work*

FROM ALL QUARTERS

Setting-up the M.o.A.

TO avoid delay in setting-up the new Ministry of Aviation the Order in Council procedure has been used. Thus, under the Minister of Aviation Order, 1959, responsibility for civil aviation and aircraft production—previously divided between the Minister of Transport and Civil Aviation and the Minister of Supply—comes under the new Minister of Aviation, Mr. Duncan Sandys. The Order transfers the civil aviation responsibilities of the Minister of Transport and Civil Aviation to the Minister of Supply, and changes the latter's title to Minister of Aviation and the former's to Minister of Transport. Separate arrangements are being made to re-allocate responsibilities hitherto exercised by the Minister of Supply which are outside the sphere of aviation, mainly the supply of conventional weapons and equipment and Royal Ordnance Factories management.

The M.o.A.—By Prince Philip

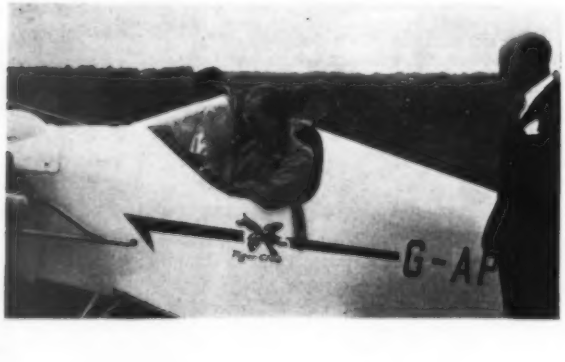
THE new Ministry was the subject of an allusion by the Duke of Edinburgh in a speech at the golden jubilee luncheon of the Air League of the British Empire, held at the Mansion House last Monday. "Whether the League breathes a fervent 'at last' or likes to take pride in the fact that it has advocated such a post for years is immaterial," said the Duke. "The fact remains that the Air League is delighted with this development."

Turning to various other matters of topical interest, the Duke spoke first of air fares, saying that the news of B.E.A.'s intention to reduce fares next summer had greatly pleased the League. On the other hand, I.A.T.A.'s refusal to recognize the force of arguments for lower fares had "highly disappointed" them, and they were now waiting with interest to see what would happen to B.O.A.C. fares which were not subject to the I.A.T.A. agreement. In a reference to air traffic control the Duke mentioned automatic A.T.C., saying that all persons and organizations working on the problem were assured of the Air League's support. Of American world competition in aircraft manufacture, this could only be tackled by governments, operators and industries working together, "and the League would definitely like to see closer co-operation within the Commonwealth." As to the R.A.F., the League was, broadly speaking, happy with the way it was getting along; there was considerable satisfaction with the new equipment for Transport Command, the projected equipment for Fighter Command, and "the existence of a specification for what is presumably a Canberra replacement."

Made from first-hand experience (see picture below) was this closing comment by His Royal Highness on the subject of amateur flying: "The League very much hopes that modern engineering ingenuity will make it possible for many more people to enjoy flying; not in the sense of being rushed backwards in the dark from one expanse of concrete to another in a different continent, but with all the gentle grace of a small aeroplane over the pleasant countryside of these Islands and the Continent—a pleasure no more expensive than yachting and far less nerve-racking than motoring."

Other speakers at the luncheon were the retiring Lord Mayor of London, Sir Harold Gillett; the Duke of Hamilton (president of the Air League) and Marshal of the R.A.F. Lord Tedder.

***IN ROYAL READINESS** to enjoy "the gentle grace of a small aeroplane over the pleasant countryside" (see his Air League speech, reported on this page): the Duke of Edinburgh in the Turbulent he flew at White Waltham last Saturday. Briefing him before flight is his equerry, S/L. J. de M. Severne; and on the right is Mr. Norman Jones, chairman of the Tiger Club and a director of Rollason Aircraft and Engines Ltd., who build the Turbulents*



Joint-venture A.T.C. Equipment

CLOSELY following the official decision to begin an Anglo-U.S. exchange of specialists and knowledge in navigation, air traffic control and kindred subjects (these pages last week) comes the announcement of an agreement between General Precision Systems Ltd. (formerly Air Trainers Link Ltd.) and Decca Radar Ltd. to co-operate in the design and production of A.T.C. equipment. General Precision Systems have for some years been a subsidiary of General Precision Equipment Corporation.

A new division has been formed expressly to provide, for both British and Continental Governments, the latest systems-engineering for A.T.C. purposes. They are already co-operating with General Precision Laboratory (part of P.E.C.), who are supplying to the Federal Aviation Agency the great data-processing and display central that is to form a basis for future A.T.C. centres in the United States. This and other developments were described in *Flight* for February 20.

The association with Decca Radar will allow the two companies to produce complete radar and information-handling installations which will incorporate the latest British and American thinking in these fields. The new General Precision Systems division is headed by Mr. E. W. Pike, a recognized international authority in this field and formerly deputy flight services manager of B.O.A.C.

Dr. E. E. Heiman: Internationalist

WE regret to record that Dr. E. E. Heiman, founder and managing director of Interavia S.A. and editor-in-chief of the Interavia publications, has died in Geneva at the age of 67. His first publication, a three-language (English, French and German) guide to the aviation institutions of the airfaring nations, was an unqualified success and his ideas received wide support.

Dr. Heiman moved to neutral Switzerland from Paris and in 1933 launched from Geneva the multilingual periodical which today bears the name *Interavia News Letter*. The guides to aviation which he had begun in Paris developed into the world-wide *Interavia ABC* directory and other publications.

IN BRIEF

By unanimous agreement of the Western European Council it was decided on October 22 to lift the ban which previously prevented Western Germany from making military aircraft and missiles.

The 50th anniversary of the first flying meeting to be held in Britain—at Doncaster from October 15 to 26, 1909—has been commemorated by an exhibition at Doncaster Art Gallery. This meeting preceded by only three days a similar one (October 18 to 25) held at Blackpool.

Last Monday's London *Daily Telegraph* reported that M.A.N., the German engineering firm, may develop and build "a Rolls-Royce supersonic engine" designated RB.153, said to be a turbojet which, by a "feathering" process, can behave like a ramjet. Rolls-Royce do not comment on this startling suggestion.

We regret to record the death of F/L. D. A. S. McKay, D.F.M., a founder-member of Air-Britain and well known as a writer on aeronautical matters. He served as a fighter pilot during the last war and from 1944 to 1954 was a flying instructor. He contributed the French and Italian sections to *Air Aces of the 1914-18 War* (published last June) and in April this year was elected Air-Britain's first honorary life member.

SENIOR NOTABILITIES: The Duke of Edinburgh presents the 1959 Gold Medal of the Institute of Navigation to Mr. J. E. Clegg of the Australian Government Weapons Research Establishment for his work on Doppler systems. (Centre) Royal Swedish Air Board officials recently visited the Marconi works in connection with the £1½m order ("Flight," October 16) for air defence equipment; here, l. to r., are Col. Hamilton and Gen. Rapp of the Air Board; Dr. E. Eastwood, Marconi chief of research; Mr. Keall, Marconi; and Col. Lindgren, Air Board. (Right) A. Cdre. J. N. H. Whitworth, C.F.S. Commandant, was among C.F.S. pilots who evaluated the Hunter Mk 66A and Gnat; he is with test pilot Bill Bedford

Sir Frank Whittle visited Bristol Siddeley Engines Ltd. on October 16 to renew an old friendship with Dr. S. G. Hooker, the company's technical director (aero). They worked closely together on the Whittle gas turbine during the early years of the war when Rolls-Royce Ltd. took over the development and manufacture of this engine, but had not met for more than ten years.

During a recent lecture to the Brough branch of the R.Ae.S., Capt. O. P. Jones (the veteran airline pilot, now engaged on special duties for B.O.A.C.) mentioned that he had first flown on his 19th birthday and had been airborne on every birthday since. The day after the lecture was his 61st birthday, and as an appropriate celebration Blackburn Aircraft Ltd. placed their executive Rapide at his disposal.

Mr. Peter Masefield will be guest of honour at the D.H. Old Boys' annual dinner at Simpsons-in-the-Strand, London, on November 7 (tickets from H. D. Wright, D.H. Technical School Office).

Dowty Group Ltd. announce that Col. C. W. King, formerly general works manager of Rotol Ltd., has resigned his position as works director of Rotol Ltd. and British Messier. Mr. A. E. Atkins, at present production controller of Dowty Equipment, becomes general works manager.

In recording the death of Elliott White Springs last week we referred to "his book *War Birds: Diary of an Unknown Aviator*." This should have read "*the* book." Springs was not himself the author, though he figured very prominently in the narrative.

Mr. Sandys and his New Task

THOUGHTS ON THE MINISTRY OF AVIATION

By FRANK BESWICK

M.P. for Uxbridge until the recent Election, Mr. Beswick (right) was Parliamentary Private Secretary to the Air Minister, then Parliamentary Secretary to the M.T.C.A., in the post-war Labour Government. Later he was chairman of the Labour Party Civil Aviation Sub-Committee.

THIS new post of Minister of Aviation is one of the most intriguing features of the new Government. It will have a political interest wider—and probably more far-reaching—than the industrial or technical questions that are raised, important though they are. The new Minister will need to develop new techniques in the relationship between government and private industry.

Ministers of Transport or of Power have a fairly clear connection with the industries for which they are responsible. They can approve, disapprove, suggest or, if necessary, issue directives. They can also hire or fire the executive heads. One way or another, if these Ministers have coherent ideas as to what should be done by their respective industries in the public interest then they have only themselves to blame if no progress is made.

On the other hand, a Minister's duties are equally clear if he has been given a mandate to transfer an industry from private to public ownership, or *vice versa*. Mr. Sandys himself had such a task when, as Minister of Supply, he was required to transfer control and capital of the steel industry.

The Minister of Aviation, however, has no precedent to guide him over the whole range of his present responsibilities. Nor has he any special directive or mandate save to improve prospects generally in the aviation business.

The post itself is one which we must all welcome. It is completely in line with what some of us on the Opposition side have been suggesting for many years. It is not the Department which will be open to question, but the policy to be devised in it. I have always been quite sure that one Minister with clear responsibility and real power was needed for both the operating and construction side of aviation. We now have to consider how Mr. Sandys will use his power, or indeed whether, on the aircraft construction side, the power is real.

Uncontroversial administrative improvements and advantages can certainly be expected now that one Minister of ability and weight can devote undivided attention to aviation. Decisions ought to be reached more quickly. Safety regulations and such things as flight-time limitations should get closer consideration. If an aircraft is to be ordered or a development contract placed, then Mr. Sandys ought now to be in a position to ensure that minds are made up without waste of time. It should be feasible to resolve possible differences between maker and user more readily under the roof of the Ministry of Aviation than round the Cabinet table, where two Ministers may be arguing conflicting cases.

Administratively the change should mean total gain. But what about policy? On the air transport side there is some, but not much, scope for Mr. Sandys' experience as a denationalizer. The Conservative election manifesto did not include the dismantling of the two national air corporations; and there would be considerable difficulties ahead if they added an amendment now, their 100 majority notwithstanding. But the Minister can claim a mandate for giving the independent operators more opportunities. Like Mr. Watkinson, he will undoubtedly be pressed to make those opportunities very wide indeed. But whilst the political arguments for "greater competition" will be put to him very starkly, Mr. Sandys will have time to ponder over some of the technical and economic aspects of the case.

The matter of traffic rights has to be taken into account for a start. Britain's control of overseas territories is not what it was, and to a much greater extent than in 1945 there are other governments who decide how many British services shall operate to or through their respective countries. Doubling the number of scheduled British operators does not mean double the traffic rights.

Moreover, all this business about generating new traffic by bringing down the fares is not as simple as some make out. The proposition makes economic sense only if the bigger aircraft are operated with a higher rate of utilization and with a higher load-factor. Optimism is a fine thing, but it will not necessarily fill all these bigger aircraft if very many more British operators are brought on to the scheduled routes.

Some people estimate that with the advent of supersonic aircraft a comparatively small fleet will be able to carry all the world's traffic. It may be too early to worry over-much about supersonic economics but it seems clear that with larger, faster, aircraft the tendency will be towards fewer operators with more capital behind them. Already this tendency is expressed in the formation and potential development of Air Union.

In short, a political election in Britain alters nothing of the transport facts of the world. Whatever licensing authority may be set up I cannot see that Mr. Sandys can deviate fundamentally from the chosen-instrument policy which was, after all, initiated by a Conservative Government.

It is when he turns to the construction side that the Minister faces his toughest problems. Let no one underestimate his task. Firms want orders; men want jobs; an industry must expect not only stability but the prospect of expansion. Mr. Sandys will be called upon to perform the difficult feat of making half, or at most three-quarters of a pint, fill a pint pot. And he does not even own the pot.

Mr. Aubrey Jones, at that despatch box in the Commons, could always shrug his shoulders and say with his half-smile that it is not his job to determine aircraft orders, but only to pass them on. But Mr. Sandys, however, is the Minister of Aviation, charged by the Prime Minister with the duty of assisting the industry. He could step up sales assistance overseas as the U.S. State Depart-

(Concluded on page 453)

Going up: A full-scale boilerplate model of the Project Mercury capsule is used in a test of the escape system at Wallops Island, Virginia. Used to separate the capsule from its booster in case of a malfunction during launching, the escape system is designed to be initiated automatically (by abort-sensing equipment built into the Atlas), by control command from the blockhouse, or by the pilot. In this sequence of photographs the pylon-mounted solid-propellant rocket fires and lifts the capsule, giving it also a horizontal displacement. (See further sequence below

Missiles and Spaceflight

MOTIVES IN SPACE

There has been a silent conspiracy amongst lawyers and writers to ignore the military purposes of space exploration and to pretend that such activities only have peaceful connotations. This was one of the main themes discussed on October 22 by Dr. Bin Cheng of University College, London, in his annual lecture in the series *Current Legal Problems* at the college.

"Space law," he said, did not exist except as a projection of the territorial laws of men in outer space. Only six months ago, Lord Hailsham's reference in the House of Lords to the U.N. Committee on the Peaceful Uses of Outer Space was greeted with laughter by the noble lords. Today all lawyers must pay serious attention to the legal problems which may be created.

The lecturer reminded the audience that every time new technological developments appeared in history they were accompanied by demands for a new system of law. For example, the discovery of the Continental Shelf and methods of underwater oil drilling created the demand from nations for a seaward extension of their national sovereignty.

Since at least two nations could now operate in space, Dr. Cheng did not think it necessary to create new systems of law, but he suggested that existing international law should adapt itself to the new problems which were being created. After a rapid review of the history of nominally-non-governmental co-operation —which made the IGY possible and included the launching of a large number of earth satellites and other artificial bodies in the solar system—the lecturer turned to examine space law from the points of view suggested by various scholars of international law.

Ethical: Although it might be ideally desirable to construct laws for outer space based on sound moral principles it was important to realize that there was no universal moral code on Earth, and there was no reason to suppose that man in space could behave differently from man on Earth towards his neighbours.

Historical: International law as a system of working rules has only had any pretence to universality since 1919. Before that time it was largely confined to the relationships between Christian European communities—who at one time were prepared to regard "discovery" of a new territory as equivalent to gaining title to the area involved. The modern view is that discovery must be accompanied by effective occupation and the intention to occupy for oneself—even if aboriginals are already there.

In principle, therefore, there is a great similarity between outer space and the New World—which, prior to its discovery, had not been annexed by any European sovereign. The *degree* of effective occupation is important since claims of sovereignty in international law depend not so much on who has *absolute* title to territory but upon who has the *better* title.

It may be significant that the Russians who have already implanted their insignia on the moon have announced that they do not accompany this achievement with a claim of sovereignty. In general States are likely to withhold their recognition of another State's claims simply to preserve the status of a disputed territory as if it were unappropriated.

Legal: Although there is no undisputed principle which declares the high seas to be absolutely free for all nations it is true to regard the high seas as something incapable of appropriation (*res extra commercium*). In this sense outer space may share a similar status.

But where does outer space commence? Most States claim exclusive sovereignty over their own *airspace*—which appears synonymous with atmospheric space. Probably the vertical limit of airspace will be determined solely by consideration of national security.

Sociological: The immense cost of space exploration makes it impossible to believe solely in non-military objectives. "National prestige" is insufficient to explain the astronomically high budgets.

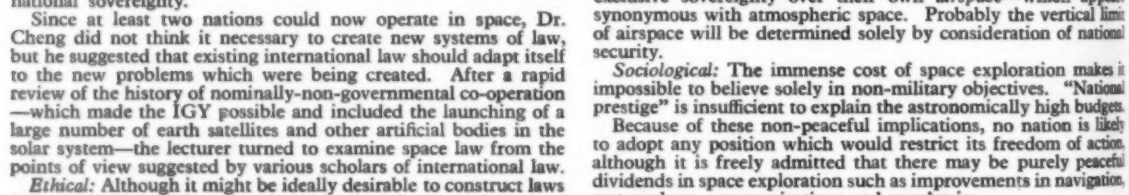
Because of these non-peaceful implications, no nation is likely to adopt any position which would restrict its freedom of action, although it is freely admitted that there may be purely peaceful dividends in space exploration such as improvements in navigation, meteorology, communications and geophysics.

Space lawyers must be mindful of this and be prepared.

COMING BACK IN

The suggestion that a new scale of speed was needed for spaceflight, possibly based on circular speed in the same way that Mach number is based on the speed of sound, was put forward by T. R. F. Nonweiler, B.Sc., A.F.R.Ae.S. in a lecture to the Astronautics and Guided Flight Section of the Royal Aeronautical Society in London on October 22. Mr. Nonweiler, who is senior lecturer in aeronautical engineering at Queen's University, Belfast, spoke on *Problems of Atmospheric Re-entry.*

Going down: At peak altitude a sensor located in the upper aerial cap fires explosive bolts, separating the "escape tower" pylon from the capsule and blowing the lid off the cap. A drogue parachute is deployed, followed by the main parachute on which the capsule descends



After listing some of the problems of heat transfer under conditions of re-entry, Mr. Nonweiler outlined the four main methods of dealing with this aerodynamic heating—(1) absorption by conductors, (2) absorption by insulators (melting or sublimation), (3) injection of air or other gas into the boundary layer to reduce the heat transfer, and (4) cooling by radiation. A sub-class under the second category was forced cooling by liquid circulation.

The peak rates of aerodynamic heating in the case of ICBMs were much greater than those for satellite and space vehicle re-entry. In general, absorption by ablation was the favoured technique for ballastic missiles (this technique was related to the total heat absorbed), while for winged vehicles it appeared that radiation cooling (in which the important factor was the *rate* of heat dissipated) was the best method. There did not seem to be any advantage in using a skip-rocket.

After considering the relative difficulty of recovery from a low, circular orbit by the various cooling techniques, and concluding that in this respect there was little to choose between them, Mr. Nonweiler discussed a number of off-design conditions. These included premature re-entry following failure during ascent; unduly steep penetration by space vehicles entering planetary atmospheres; and the effect of altering the all-burnt angle of inclination and speed on surface temperature and retardation of a ballistic missile.

In the case of a premature failure or a too-violent injection, the ablative shield would stand up best to the emergency. The total heat to be absorbed would not increase, and might in fact be reduced. On the other hand the high retardations involved would make this method inadvisable for re-entry of a manned vehicle, in which case a lifting vehicle was indicated.

Concerning re-entry from a parabolic orbit, the technique of a braking ellipse was not now favoured—in the case of a manned vehicle, for instance, the danger of repeated passes through the radiation belts was obvious. Mr. Nonweiler concluded by discussing the problem of navigation prior to re-entry, referring to the paper presented by Dean R. Chapman of NASA at the recent I.A.F. congress in London. The accuracy imposed by a re-entry corridor 50 miles wide, at escape velocity, was equal to 2 min of arc at ten Earth radii assuming zero speed error; or 0.3 per cent on speed assuming correct alignment.

NASA GAINS VON BRAUN TEAM

President Eisenhower announced on October 21 that, subject to the approval of Congress, the team of some 5,000 scientists led by Dr. Wernher von Braun and forming the Development Operations Division of the Army Ballistic Missile Agency at Huntsville, Alabama, would be transferred to the control of National Aeronautics and Space Administration. This would consolidate under NASA the development of the next generation of large space vehicles.

Dr. von Braun's team, who were responsible for developing the Redstone and Jupiter IRBMs (and incidentally for putting the first U.S. artificial Earth satellite in orbit), have had as their main current task the development of the massive Saturn space vehicle, the first stage of which is to comprise a cluster of eight H-1 engines totalling 1.5 million pounds thrust. On October 22 President Eisenhower said that the purpose of the transfer of the Army team to NASA was to enable it to concentrate on "one powerful booster." The primary place of the booster was in space exploration, not in the missile programme, and that was why it was to be a civilian project. Also on October 22 the President said that he would ask Congress for higher appropriations next year for the U.S. space programme.

Men of Saturn: (from the left) Karl L. Heimbur, chief of the ABMA test laboratory at Huntsville, Alabama; Dr. Wernher von Braun, director of development operations, ABMA; and Maj-Gen. J. B. Medaris, commander, Army Ordnance Missile Command, seen with Saturn and Jupiter models (see "NASA Gains von Braun Team")

The premature retirement at his own request of Maj-Gen. J. B. Medaris, commander of the Army Ordnance Missile Command, which was announced on October 19, was taken generally as a criticism of the way the U.S. space programme was being run and in particular of the reduction of funds for Saturn, although the general said that his reason for resigning was not disgruntlement over recent developments. Commenting on Gen. Medaris' resignation, Dr. von Braun said that it was quite possible that within two years the Russians would be able to put "a busload of astronauts" into space. Under the present U.S. programme it would take 4-5 years to develop a rocket powerful enough to match this feat, and three years even if extra money were provided.

"If we continue at this leisurely pace we will have to pass Russian Customs when we land on the Moon," he said. Concerning rumours that Dr. von Braun was planning to enter private industry, he said that he had no intention of leaving ABMA, but that he might do so if the Saturn project were cancelled or if his team were not given a "sufficiently challenging project."

Earlier, Lt-Gen Arthur Trudeau, U.S. Army chief of research and development, had said that it would take at least three years at the present rate of development to launch the Saturn rocket with a "meaningful" payload. Complaining of a shortage of funds for this project, Gen. Trudeau estimated that even with "sufficient" money the time to reach launching potential would be 1½-2 years.

It has been unofficially reported that the Saturn project was cut by almost half this year by the Defense Department, from $135m to $70m. This reduction, it has been suggested, has already resulted in a delay of between seven months and one year.

MR. SANDYS AND HIS NEW TASK (continued from page 451)

ment is said to be doing. He might even devise ways of further improving extended-credit facilities. He might get his colleagues seriously to seek Commonwealth co-operation and explain to them that we could expect a British Dominion to give priority to our aircraft if we were prepared to buy their butter.

Mr. Sandys might get more from Mr. Heathcoat Amory for research and development. In that he should have an ally in the restless Lord Hailsham. After all, the new Minister for Science must have some interest in helping the industry which more than most others should inspire and use the scientific and technological processes that he is asked to foster.

But when all is said and done, how is the industry itself to be made more efficient or effective? Can, or should, Mr. Jones's process of rationalization be hastened? It will not be easy. Apart from his personal persuasiveness, the Minister can presumably apply, indirectly, financial pressure. But one curious feature of the industry is that some units with apparently smaller technical resources are financially the most resilient.

And if by one means or another the Minister is to find additional finance for the industry—by development or prototype contracts or otherwise—how will he ensure that he gets value for money? Has he new ideas for penalty clauses?

The device of the commission on sales in return for State financial assistance has pleased few people. In a very limited number of cases the State has done very well by this arrangement—and the firms concerned have felt themselves to be drained unfairly. In a majority of cases the State's version of the arrangements is "tails they win and heads we lose."

These considerations have been important in the past and the sums involved have been large indeed. But if we move (as inevitably we must) into the supersonic club, then post-war investments will seem minute. The State cannot be content simply to write out cheques. Nor can the answer be an army of inspectors to check on progress. We have all spoken of the need for partnership between State and industry. It will be of more than passing interest to see how Mr. Sandys now spells this out.

Just one final thought about rockets. A supersonic transport *and* a cosmic space programme are too much to expect, even from a new Department. But Mr. Sandys spent some years of his earlier life in furthering the cause of federalism. If any project needed to be tackled on federal lines, surely it is the effort of this planet to make contact with others.

It is not for me here to say whether the federation should be of West European, of North Atlantic, or of Commonwealth countries. After all, even Soviet Russia has made a definite offer for a joint programme—though she did tie strings about foreign bases. But the possibilities open up one more opportunity for Mr. Sandys' abilities. And for the time being, at any rate, we all wish him well.

Two manpowered aircraft projects, the Hartman ornithopter (left) and the Perkins inflatable-wing machine (minus propeller)

THE MUSCLE-MEN EMERGE

AS an incidental preliminary to the first meeting of the Manpowered Aircraft Group of the Royal Aeronautical Society (tonight, October 30), two British manpowered aircraft have been "unveiled." The aircraft concerned are the ornithopter devised by Emiel Hartman, a London sculptor, which was taken to the College of Aeronautics, Cranfield, and carried out taxying trials there on October 20; and the inflatable fixed-wing aircraft designed and built by Daniel Perkins, a senior experimental officer at the Royal Aircraft Establishment.

Detail design and complete construction of the Hartman ornithopter were carried out by Don Campbell, the well-known "Glider Doctor," of Hungerford, with additional stress calculations by Aviation and Engineering Projects Ltd. of Hounslow.

As indicated in the sketch, the flapping action of the wing is obtained by a rowing action of the pilot's arms, which hold special hand-grips attached to the parallelogram linkage. Elevator control is by twisting the hand-grip in the same manner as a motor cycle twist-grip throttle, and rudder control is by rotating the grips about a near-vertical axis. The trailing-edge "feathers" impart a valve action, partially closing on the downstroke and opening on the upstroke.

The Perkins inflatable-wing machine is expected to weigh less than 100 lb when complete (the pusher propeller has yet to be installed). The designer has had experience in the development of previous inflatable-wing aircraft, and has devised a special form of transmission to couple to the propeller the bicycle pedals by which the manpower will be exerted. Unlike the Hartman ornithopter, this aircraft is designed to take off by pilot-power alone.

Brief details of both machines are given below, followed by a comment on the Hartman machine, and on ornithopters in general, by David Rendel, B.A., A.F.R.Ae.S., A.M.I.Mech.E., of the Royal Aircraft Establishment, Farnborough, who was secretary of the original Manpowered Aircraft Committee.

Hartman Manpowered Ornithopter Power, rowing action by arms, to flap wings; span, 36ft; mean chord, 4ft; weight, 282 lb; construction, as conventional glider (4,600 man-hours); design begun, February 1958; construction period, March-September 1959.

Perkins Manpowered Aircraft Power, cycling action by legs, to drive pusher propeller; span 39ft; mean chord, 2ft 6in; weight, under 100 lb; construction, inflatable rubberproofed-cotton wings (variable incidence), light-alloy framed, rubberproofed-cotton-covered fuselage, no horizontal tail surface; design begun, October 1958; construction begun, February 1959

Technically speaking the flapping wing has a number of major advantages over other means of propulsion at low speeds. The aerodynamics of this type of propulsion have been considered briefly by various authorities in Germany, France, Russia and Britain, and the results of these studies show that, for non-permeable propulsive wings such as those of insects and bats, propulsive efficiencies of 80 to 90 per cent can be achieved if the forward speed is kept low and if the wing is correctly twisted during the flapping motion. It also appears that oscillation of the wing can delay the build-up of induced drag so that much higher values of L/D may be possible if the wings are continuously flapped (this is known as the Katzmayr effect). There might even be some prospect of recovering energy from the air by means of these oscillations by using the aero-elastic properties of the wing.

When we turn to the permeable wing as used by birds, we find that the possibilities of boundary-layer control with a system of elastic feathers can greatly increase the lifting power of the wing. Since the wing surface is oscillating normally to the air, it becomes possible to pump the boundary layer in and out of the passages between the feathers during each stroke. Birds using this technique have been shown to achieve lift coefficients two or three times as great as would be expected if the wing had been non-permeable, and Russian experiments in sticking the feathers of birds together have shown that for some birds flight without this boundary layer control is impossible.

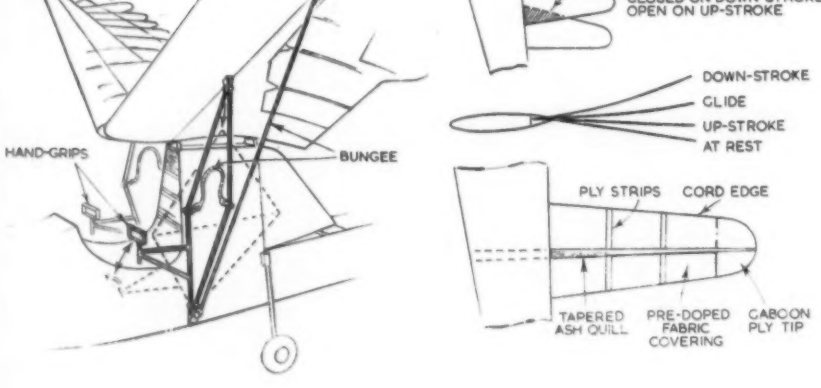
If the oscillating wing can be combined with a flexible structure such as a system of feathers on an elastic surface, further great advantages accrue through the ability to vary the wing geometry to meet the particular flight condition involved.

Hartman's aircraft appears to have non-permeable inelastic wings, and so it will not be able to benefit from many of the advantages described above. Furthermore it has apparently no built-in twisting mechanism, and therefore may not achieve the high values of propulsive efficiency which are theoretically possible.

One of the features of the aircraft which distinguishes it from all other attempts in this sphere (with the exception of an experimental apparatus built by Mr. P. A. Barnes of Peterborough), is the incorporation of an elastic suspension system, whereby the wing oscillates in resonance with the natural frequency of stretched bungee cords adjusted to conform to the natural frequency of movement of the human body when working in the rowing attitude.

It can be shown by quite simple aerodynamic calculation that, for a given wing geometry and wing loading, the speed of flapping necessary to achieve flight with a given ratio of power output to mass varies inversely as a high power of the span. For a wing half-span of 8ft, for instance, the flapping speed required will be about 100 deg/sec. At 20ft half-span this drops to around 20 deg/sec, while for small spans of a few inches the flapping speed rises very steeply and will be many thousands of degrees per second. Fortunately the inertia of the wing varies in a similar manner, so that it is in fact possible to achieve the optimum flapping speed at all scales from the aphis to the albatross.

For man the aerodynamically optimum flapping speed comes out at between 30 and 40 deg/sec, or roughly one-half flap per second when in level flight. This conforms to the rate of natural movement when rowing (as those who have listened to boat-race commentaries will know) and also to the elastic support system built in to Hartman's aircraft. Thus the man, the machine and the air are, as you might say, all in resonance with each other—and this should lead to considerably more efficient power utilization. It may also be found that better power production is possible in this way.



Hartman ornithopter details: (far left) wing-beat action—up 30 deg and down 10 deg—and parallelogram operating-strut linkage; (left) feather valve action, quill bending and feather construction. Quills are sized to suit air loads and give appropriate bend, and offset to give sufficient twist to close the valves on the downstroke

TURBOFANS

A Survey of Current Airline Powerplants

By the Technical Editor

ILLUSTRATED WITH "FLIGHT" COPYRIGHT DRAWINGS

ON May 9, 1956, Trans-Canada Airlines ordered four DC-8 aircraft powered by Rolls-Royce Conway engines. Although not a particularly large contract, it is historically one of great significance; for, typifying the courage of the company's president, Mr. Gordon R. McGregor, in backing new technological developments, it was the first occasion on which an operator had ordered an aeroplane powered by double-flow engines. What is meant by this term is explained below.

In the propulsion of any aeroplane the overall efficiency of the powerplant system can be assessed under two main headings: the internal (e.g., thermal) efficiency of the engine; and the propulsive (Froude) efficiency. Clearly it is desirable that both should be as high as possible.

Thermal efficiency is increased by raising both the engine pressure ratio and the difference between intake temperature and maximum gas temperature. Thus, for subsonic aircraft, it is desirable to design the compressor to achieve a pressure ratio of at least 13:1; while, in order to achieve the highest possible rise in temperature in the working cycle, air-cooled turbine blades may be employed to permit operation at gas temperatures of at least 1,250 deg K, without shortening blade-life.

In order to raise the Froude efficiency it is desirable for the velocity of the jet which propels the aircraft (by "jet" we mean, in this context, the entire mass of air which is accelerated to the rear by the propulsive system of the aircraft) relative to the surrounding atmosphere to be as near as possible to the forward velocity of the aircraft, again relative to the free air.

This condition is almost achieved in such machines as the Britannia and Vanguard, in which large propellers handling an enormous mass-flow of air propel a fast-flying aircraft. Examples of poor Froude efficiency are provided by a number of slow-flying machines powered by turbojet or rocket engines, in which the jet velocity is inevitably several times the airspeed of the aircraft. For transport purposes it is today desirable to cruise at speeds too high for a conventional propeller; yet in order to increase Froude efficiency it is essential to make a turbojet behave as much as possible like a turboprop by increasing the amount of air with which it deals, and by reducing the mean jet velocity.

Much confusion has arisen through the fact that double-flow turbojets are already referred to variously as turbofans, fan engines, ducted fans and by-pass engines. All, however, operate on essentially the same principle.

For instructional purposes Fig. 1 shows a simplified front-fan engine with geometry distorted for clarity. Atmospheric air A enters the intake and passes through the two stages of fan blading B. The delivery from this fan (which may be regarded as an enlarged low-pressure compressor) is divided, some passing along the outside of the engine through the by-pass duct C, and some going through the high-pressure compressor D. The latter flow then goes through the combustion chamber E, to which fuel is pumped from the manifold F, and is finally expanded through the high-pressure turbine G and low-pressure turbine H. The hot gas then escapes through a propelling nozzle, surrounding which is an annular nozzle for the cold flow.

In this example the fan is a separate assembly driven by turbine H. That this need not be the case is shown by reference to the drawings of Pratt & Whitney engines in which the fan stages are bolted to the front of a low-pressure compressor.

In the design of a double-flow engine there are two major variables. The first is whether to put the fan at the front or at the back, and later in this article General Electric's preference for the latter configuration is explained. The other major variable is the choice of C/H ratio. This is also known as by-pass ratio, fan ratio, cold-flow ratio, or augmentation ratio, but the author favours C/H (cold/hot) ratio, since this is unambiguous. In case any reader feels otherwise, it means the cold flow through duct C expressed as a ratio of the hot flow through duct D.

Choice of a high C/H ratio provides increased economy, but the large mass-flow per unit thrust leads to high intake momentum drag (engine mass-flow multiplied by flight speed). This in turn results in a more rapid decay of thrust during the course of a take-off than would be suffered with a straight turbojet, in which mass-flow for the same thrust is appreciably less. In the Rolls-Royce engines the C/H ratio is relatively low, and in the latest powerplants—such as the RB.141—the ratio has been chosen to provide maximum installed propulsive efficiency.

The two sets of curves published as Figs. 2A and 2B illustrate the basic effect on performance of variation in the C/H ratio. The former diagram is based on a sketch by Bristol Siddeley, and the latter comes from a paper read before the Royal Aeronautical Society by Peter Lloyd of the National Gas Turbine Establishment. Specific thrust is, of course, the reciprocal of mass-flow per unit thrust, from which it can be seen that as specific thrust is reduced (to give minimum s.f.c.) the momentum drag is correspondingly increased.

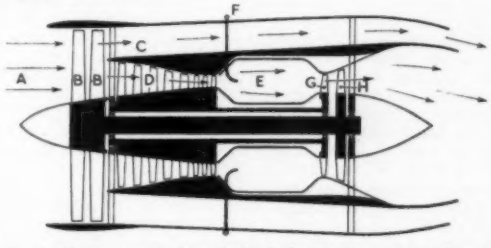


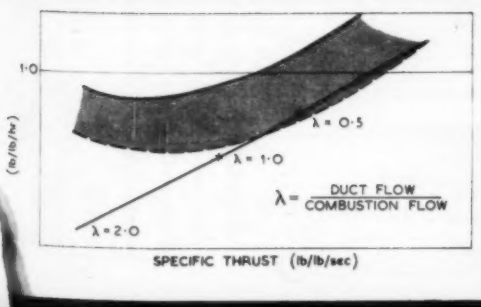
Fig. 1. A diagrammatic hypothetical double-flow engine (see text)

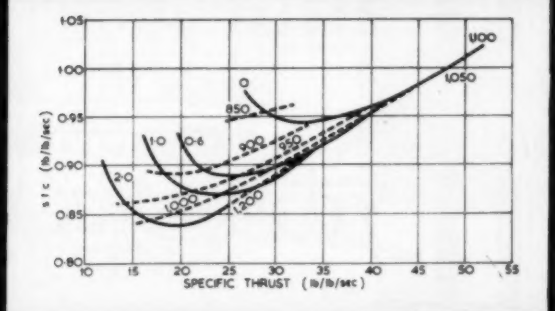
Having conveniently disposed of theory, attention may be turned in the remainder of this account to what has actually been built. As he reminded us in a letter published on October 9, Sir Frank Whittle was the originator of the double-flow principle; and, as a result of his work, Power Jets (Research and Development) Ltd. still hold the basic patents relative to what were then called by-pass engines. The first manufacturer actually to build and fly such an engine was the Société Turboméca, whose Aspin was running on the bench only four years after the end of the war in Europe. At an even earlier date Metropolitan-Vickers had evolved the exceptionally advanced F.3 and F.5 aft-fan engines, but although both reached an advanced state of development (being based upon the well-known F.2/4 Beryl turbojet) neither flew. This journal described the F.3 in detail.

It thus fell to Rolls-Royce to initiate the line of development which led to the first double-flow engine to enter service. Their work started not so much by making a pure turbofan as by increasing the capacity of the initial stages of the low-pressure compressor of an otherwise conventional two-spool turbojet, and by-passing the excess air around the remainder of the engine. After having a number of experimental RB numbers (Rolls-Barnoldswick, from the company's research and development centre) the first by-pass engine was named Conway.

In its original form almost a decade ago, the Conway was not greatly different from a simple turbojet, in that the C/H ratio was

Figs. 2A (left) and 2B. Curves of basic performance: in 2A may be seen C/H ratios of 0.5, 1 and 2 plotted against straight turbojets (shaded); in 2B, based on 500 kt at 36,000ft, figures indicate C/H ratios of 0, 0.6, 1 and 2, and top temperatures up to 1,200 deg K.





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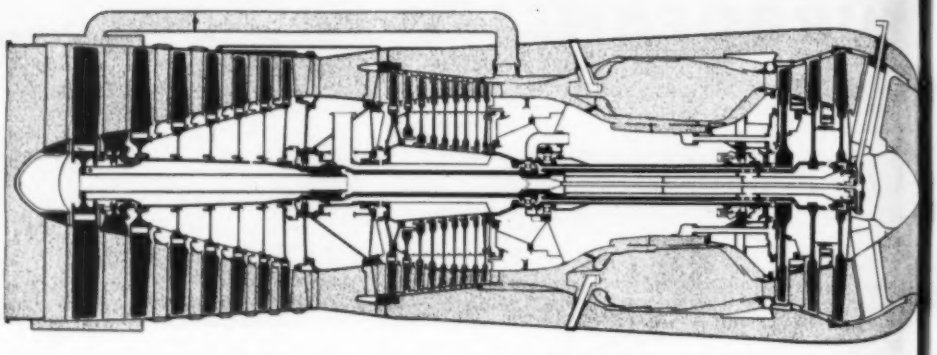


Fig. 3. The Rolls-Royce Conway has not previously been shown in cross-section. This is the current RCo.10-11-12 engine rated at 17,250 to 18,500 lb guaranteed minimum. Although the C/H ratio is only 0.3 the cold flow has very high pressure, since it is compressed by all seven l-p. stages. The external pipe is for anti-icing

only 0.23. At this time the engine was rated at 9,250 lb static thrust, and by 1952 it had been chosen to power the projected Vickers-Armstrongs V.1000 transport. As this aircraft grew during its formative years so was the Conway refined and enlarged, until by the time it was type-tested in 1955 the RCo.5 rating was 13,000 lb. This was achieved with an s.f.c. lower than that of any other type-tested turbojet. Since then the same basic engine has been further improved.

Current deliveries are of the Conway 505 and 507, for the Boeing 707-420 and DC-8 respectively, together with the military 200-series of RCo.11 rating at 17,250 lb for the Victor B.2. For Douglas, Rolls-Royce supply completely equipped engines for installation in DC-8s; for Boeing they manufacture the complete nacelle, thrust reverser (which handles the entire mass-flow of the engine) and noise-suppressing nozzle. Originally the Conway 505 and 507 were to be delivered at the RCo.10 rating of 16,500 lb, but flight-testing in Ashton and Vulcan aircraft, and carefully instrumented running in the company's high-altitude plant, has been so outstandingly successful that current deliveries are rated at the RCo.12 level of 17,500 lb (Fig. 3).

By incorporating redesigned blading in the initial stages of the low-pressure compressor, the RCo.12 can be converted at overhaul to the RCo.15 rating of 18,500 lb guaranteed minimum. The corresponding engines are the Conway 508 and 509. By the same token, either the RCo.12 or RCo.15 standards of build can be converted to the advanced RCo.42, although in this case modification is rather more extensive and the low-pressure compressor is entirely new. Rated at 20,250 lb guaranteed minimum, the RCo.42 has been chosen as the Mk 540 engine for the Vickers-Armstrongs VC.10.

Chronologically the next family of double-flow engines upon which work was started is that evolved by Pratt & Whitney Aircraft from the basic JT3 (J57) turbojet. Spurred on by the prospect of mounting competition from Rolls-Royce with an inherently more efficient powerplant, the American company produced a front-fan engine, capable of being built up from the JT3C turbojet by a kit of parts and instructions sent to operators at a major overhaul.

Known as the JT3D (military, TF33), the Pratt & Whitney turbofan (Fig. 4) differs from the basic turbojet in having an entirely new intake, low-pressure rotating assembly and cowling. As was narrated at length in our issue of December 19, 1958, the first three stages of the low-pressure compressor are replaced by two large-diameter fan stages (this blading was originally developed for the J91 nuclear turbojet, now defunct), while the second stage of the original low-pressure turbine is replaced by two new stages, driving through a strengthened shaft to transmit the increased power. A cutaway drawing of the JT3D appeared in our special "Aero Engines of the World" issue of March 20.

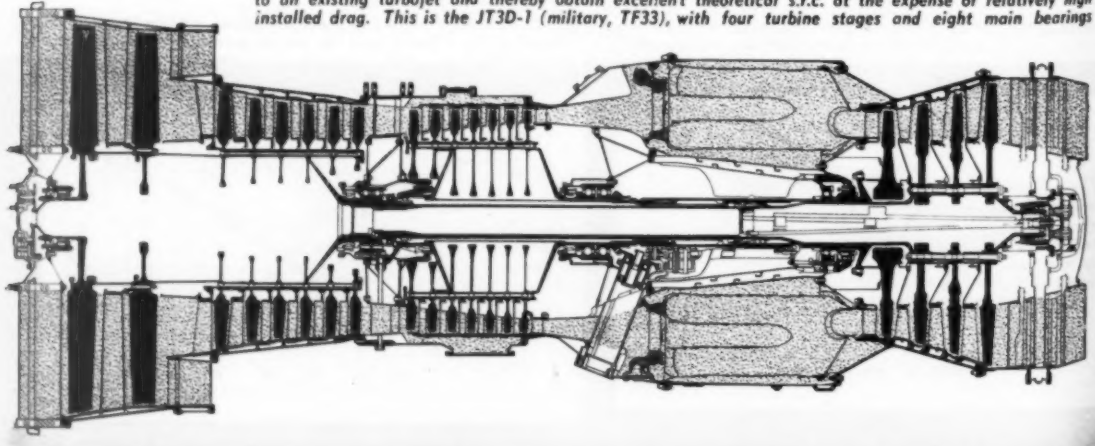
First and foremost among the factors in favour of the JT3D is the fact that it is not an entirely new powerplant but merely a major modification of an engine which has already run at least 180,000 hr in scheduled service and has shown reliability commensurate with the reputation of its manufacturer. Allied with this is a brochure performance of considerable merit, stemming from the high C/H ratio and inbuilt pressure ratio. Disadvantages include a tendency to undue complexity, a rather large frontal area, the fact that the by-pass air renders the engine installationally difficult and the fundamental disadvantage that the addition of the fan at the front requires the complete mechanical and aerodynamic redesign of all the engine behind it.

Provided that the ratio of the pressure-ratios of the high-pressure and low-pressure assemblies is suitable, it can be shown that for maximum overall efficiency the cold and hot flows should be mixed upstream of the propelling nozzle. This also has the advantage of reducing the noise-level to well below that generated by the hot central jet alone. Pratt & Whitney found from tunnel testing that, for minimum cruising drag, the optimum pylon-hung nacelle for the JT3D should have a conventional nozzle for the hot flow and lateral elephant-ear ducts for the cold flow (Fig. 5). Although the short ducts for the cold flow are aerodynamically efficient the arrangement renders the achievement of thrust reversal exceedingly difficult. In fact, Douglas Aircraft have elected to duct the cold flow from the JT3D to the rear of the nacelle in re-engined DC-8s.

Selling points emphasized by Pratt & Whitney are that the JT3D-1 "delivers 42 per cent more take-off thrust and operates on 13 per cent less fuel than the latest JT3 jet engine . . . the new engine handles 140 per cent more air . . ." Two variants are currently under development for commercial purposes. The JT3D-1 is due to be delivered next July and the advanced JT3D-3 is to be delivered from July 1961. Initial overhaul life is expected to be "comparable to that of the JT3C series." Development of the military TF33-P-1 is progressing rapidly, and the first specimen flew beneath a B-45 test bed (the first U.S. double-flow engine to fly) late in July. Deliveries for B-52H aircraft start at the end of 1960.

Third contender to enter the fan field was the Aircraft Gas Turbine Division of the American General Electric Company. For more than two years, the advanced single-shaft, variable-stator J79 military turbojet has had a commercial counterpart designated CJ-805 under development in parallel. Inheriting the light weight and clever engineering of the J79, the commercial engine was certificated in September 1958 and is now already at the airline crew-training stage in Convair 880s. But G.E. appreciated that the future lay with the fan, and they evolved an aft-fan engine as a simple addition at the rear of an otherwise unchanged CJ-805.

Fig. 4. In sharp contrast to the Rolls-Royce formula, Pratt & Whitney have elected to add a front fan to an existing turbojet and thereby obtain excellent theoretical s.f.c. at the expense of relatively high installed drag. This is the JT3D-1 (military, TF33), with four turbine stages and eight main bearings



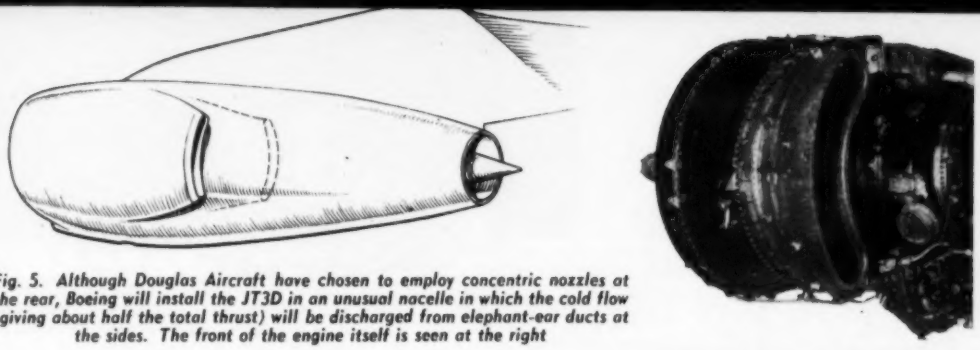


Fig. 5. Although Douglas Aircraft have chosen to employ concentric nozzles at the rear, Boeing will install the JT3D in an unusual nacelle in which the cold flow (giving about half the total thrust) will be discharged from elephant-ear ducts at the sides. The front of the engine itself is seen at the right

Current aft-fan units are designated CJ-805-21 and -23 (military nomenclature, TF35); the former was extensively discussed in our issue of December 26 last, and the configuration is depicted in Fig. 6. It will be seen that behind the basic turbojet has been added an independent free-floating assembly of double-deck blades (Fig. 7) comprising inner turbine blades extracting power from the hot jet and outer fan blades transmitting power to a large mass-flow of cold air. The latter is drawn in to an annular intake surrounding the remainder of the engine and, after passing through the fan, is immediately discharged around the hot core.

Reverting to fundamentals: in the evolution of a fan engine from a turbojet it is the designer's aim to reduce the mean jet velocity and increase the mass-flow handled, and this inevitably involves the extraction of additional shaft power from the original jet. In the Pratt & Whitney engines additional turbine stages are added to accomplish this and their power is passed to a fan at the front. In the G.E. engine a single turbine stage is added, to the rear of the original three-stage wheel.

At present most fan engines are being produced by modifying existing turbojets, and probably the most fundamental single question to be resolved in effecting the conversion is whether the fan should be added at the front or at the back. Of the four major manufacturers of turbofans, three have elected to do the former; but General Electric, who for four years have been studying both layouts, have come down heavily in favour of "putting the fan in back." The following are some of the reasons which have led them to this decision.

First and foremost, the aft-fan formula is the only practical manner in which the mechanical design and operating characteristics of the basic turbojet can be retained virtually unaltered. Addition of a front fan changes the aerodynamic behaviour of the entire engine, and is almost bound to modify the loading on all shafting, bearings and supports, bearing housings, seals, frames and most other portions of the carcase. Moreover, as inspection of the drawings reveals, as many as eight main bearings may be required (three more than in the General Electric engines). With an aft fan a designer has greater freedom in selecting C/H ratio, fan speed, diameter and pressure ratio, without being crippled by the necessity to maintain compressor tip speed while restricting tip speed of the fan to an acceptable level. In a front-fan engine the polar moment of inertia of the main rotating assembly is very great, and during acceleration the turbine has to extract increased power to pump the fan air. With an aft fan increased power must also be extracted, but the complete mechanical independence of the two rotating assemblies is likely to improve engine acceleration. With the CJ-805 the additional refinement of variable stators permits full power at sea level to be obtained 5.6 sec from idling at 900 lb.

There are, of course, drawbacks; and it cannot have been an easy job to match the basic CJ-805 to the added double-deck blades with the latter working in gas already expanded and cooled. These blades, incidentally, are colloquially known as "bluckets" at G.E., from a corruption of blades and buckets (the latter being Americanese for turbine rotor blading). Shown in Fig. 7, the blades posed considerable design problems, and 54 of them are used in the CJ-805-23 fan. Overall fan diameter is 48.8in and at 5,636 r.p.m. the tip speed is 1,190ft/sec. Proponents of the front fan and aft fan will probably never agree on which type of blading is the more difficult to design. It is, however, valid to claim that the aft fan is self anti-icing.

The first aircraft to be designed around the new G.E. engine is the Convair 600 (see table). As Fig. 8 shows, the CV-600 installation is neat and provides for thrust reversal of both the hot jet and the cold surrounding air. G.E. have also studied alternative nacelle installations in which the fan air is induced from a variety of types of rear intake.

From the foregoing it can be seen that by the beginning of 1959 Rolls-Royce, Pratt & Whitney and G.E. were all forging ahead with double-flow engines against firm orders from the airlines. Since that time they have been joined by the new British giant of Bristol Siddeley Engines, who have already evolved a very attractive front-fan engine using "a large number of components identical, or closely similar, to those already proven in tens of thousands of hours of operational service."

Although details remain classified it seems clear that the progenitor of the new Bristol Siddeley family is the BE.53. This unit is intended to provide a plurality of hot and cold flows, which may be diverted by valving to provide either forward thrust or

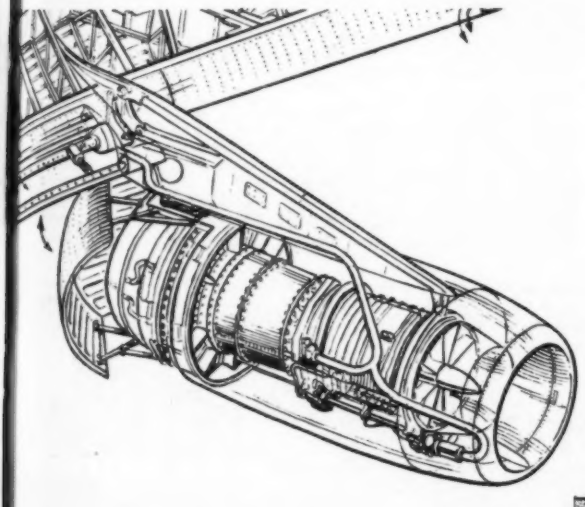
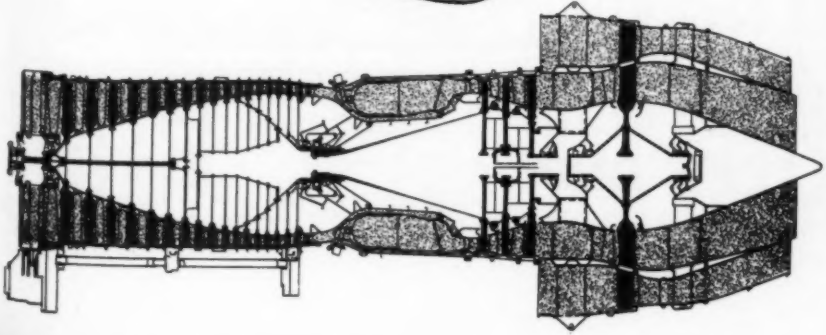


Fig. 6 (below). The G.E. CJ-805-23 aft-fan engine

Fig. 7 (right). One of the "bluckets" for the CJ-805-23; the operating temperatures are 200 deg F outboard and 950 deg F inboard

Fig. 8 (left). The installation of a CJ-805-23 in the CV-600 (starboard inner is shown)



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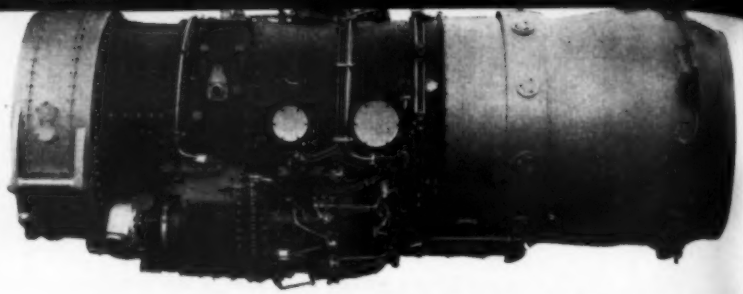
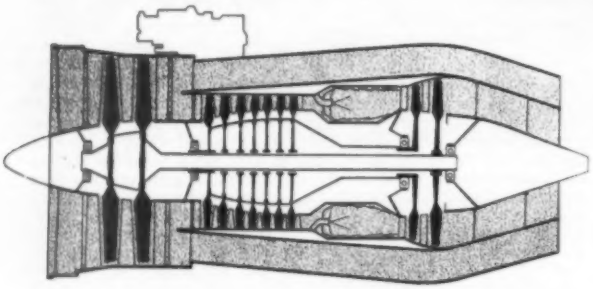


Fig. 10. Rolls-Royce are not yet prepared to release details of the design of the RB.141, although new data are given in the table on p. 459. This photograph depicts an engineering mock-up

Fig. 9 (below). First of the new turbofans by Bristol Siddeley to be illustrated, the BE.58 is unusual among such engines in having but two stages of turbine blading



vertical lift. As such it appears to be the engine selected for the Hawker P.1127 VTOL strike/fighter, and is therefore in receipt of financial assistance under the Mutual Weapons Development Programme. This places the company's new engines on a sure foundation.

The commercial unit which has been announced is designated BE.58 (Fig. 9), and one is led to suppose that the two powerplants are very closely related. Bristol Siddeley are known to have designed a range of turbofans of different thrusts, and it is likely that a number of these follow the same formula as the BE.58. In the latter, the front fan is independently driven by its own turbine, through the centre of the compressor/turbine "boiler" unit, and supercharges the latter, as well as providing the cold flow which may be either led to lateral nozzles, or mixed in a single propelling nozzle at the rear. In the latter case there would appear to be no barrier to the achievement of reverse thrust on both hot and cold flows. The C/H ratio of the Bristol Siddeley unit has been stated to lie between 1.5 and 2, resulting in excellent propulsive efficiencies up to Mach numbers of the order of unity.

No certification schedule for the BE.58 has been announced, but in view of the fact that—as implied above—it utilizes major portions of the thoroughly proven Orion/Orpheus/Olympus engines, its development should be relatively rapid, which in turn should be reflected in a reduced selling price. This is a factor of critical importance.

Although backed on the military side, Bristol Siddeley have yet to achieve commercial sales for their new fan engine. Fortune has so far favoured Rolls-Royce. By 1957 Rolls-Royce thinking in the field of transport propulsion could be summarized in the following terms: "We know how to make engines of very high pressure ratio (Tyne). We know how to make engines with air-cooled turbine blading and very high top temperature (advanced military Avon). We know how to make a by-pass engine (Conway). No other company in the world combines this knowledge. Starting with a clean sheet of paper we can design the optimum powerplant for a high-subsonic airliner which will surpass the best that any other firm in the world can achieve."

Not yet given a river-class name, this optimum engine bears the Rolls-Barnoldswick number of 141, and its bench trials begin in a few days' time. As Fig. 10 indicates, its external appearance is not dissimilar to that of a modern turbojet, for Rolls-Royce have not gone overboard in choosing C/H ratio but have selected the moderate value of 0.7. Like the Conway, the 141 comprises a fan and low-pressure compressor followed by a high-pressure compressor, the by-pass air being ducted aft within the casing of the engine and mixed with the hot jet in the final nozzle. The latter can readily incorporate thrust-reverse for both hot and cold flows, but a noise-suppressor appears unnecessary.

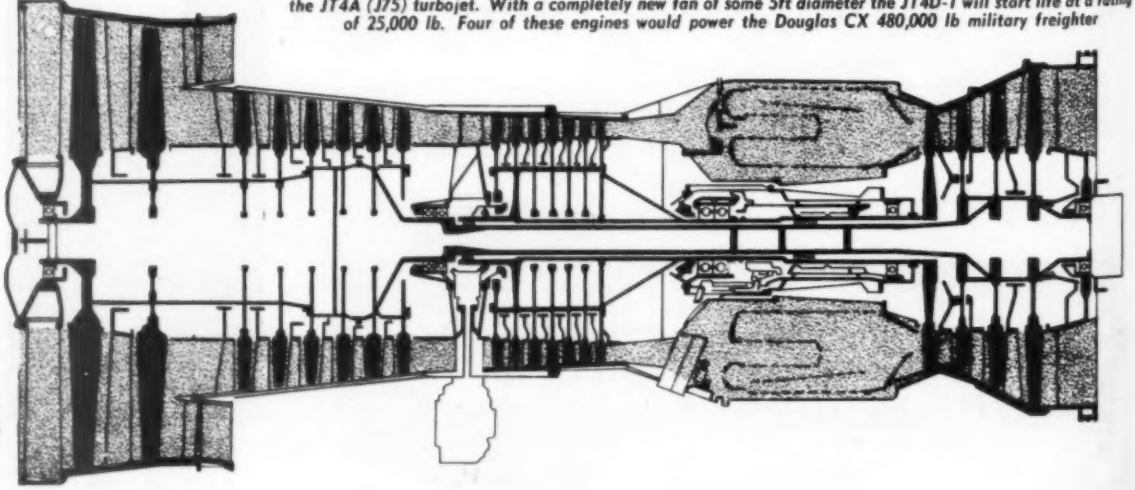
Originally the RB.141 was sized to match the thrust requirements (for take-off, cruise and the engine-out case) of the three-engined Airco D.H. 121 and of the Caravelle 7. In the event, B.E.A., the sponsors of the 121, decided that they wanted a smaller aeroplane, and this has led Rolls-Royce to produce a scaled-down 141, designated RB.163. Rated for the D.H. 121 at 10,100 lb dry thrust, the 163 will conform closely to the 141; in fact, Rolls-Royce regard it as being the smallest member of the 141 family, which covers a range from 10,000 to 17,000 lb thrust.

Meanwhile, their great rivals in East Hartford have to some extent gone fan mad, since a double-flow derivative of every current Pratt & Whitney turbojet appears to be in the running as a firm project. The basic engines are the JT4 (J75), JT8 (J52) and JT12 (J60); and there is probably even a paper fan version of the Navy's J58, designed for M 3.

Largest of the new Pratt & Whitney fans is the TF75 (commercial designation JT4D), which is a straight conversion of the J75/JT4A, following the formula proven with the J57/JT3. The company have no contract for this work and are unlikely to take it to the hardware stage without military backing or assurance of substantial civil sales. The simplest conversion is the addition of the front fan of the JT3D-1 on to a basic J75 or JT4A-9. This is rendered possible since the hub diameter of the two compressors is essentially the same. Compared with the JT4A-9 this somewhat compromised turbofan will have 8 per cent better s.f.c. It is designated JT4D-3 and would be rated at 22,500 lb. The optimum JT4D-1 (Fig. 11) would have a new *ad hoc* fan of appreciably greater diameter. The sea-level rating would be 25,000 lb, and cruise s.f.c. would be approximately 15 per cent better than that of the straight turbojet.

The military TF75-P-1, corresponding to the JT4D-1, is the engine specified by Douglas for the larger of their two CX military freight aircraft, in which four of these big engines would be installed in twin pods. In their submission to the U.S.A.F. for this aircraft last August, Douglas said: "The turbofan power system was chosen for the future cargo airplane because it provided the most favourable balance between speed, productivity and direct operating cost for the design cargo/range mission.

Fig. 11. Largest engine currently planned for transport use, the Pratt & Whitney JT4D-1 is a conversion of the JT4A (J75) turbojet. With a completely new fan of some 5ft diameter the JT4D-1 will start life at a rating of 25,000 lb. Four of these engines would power the Douglas CX 480,000 lb military freighter



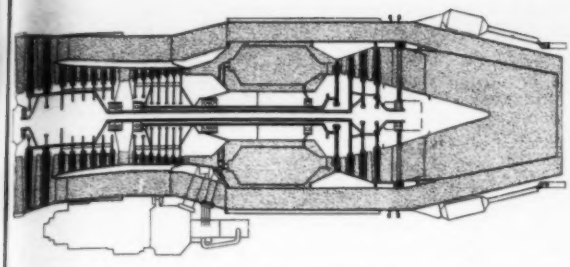


Fig. 12. Scheduled to power the Douglas DC-9, the Pratt & Whitney JTF10A employs a by-pass duct leading to a rear annular nozzle

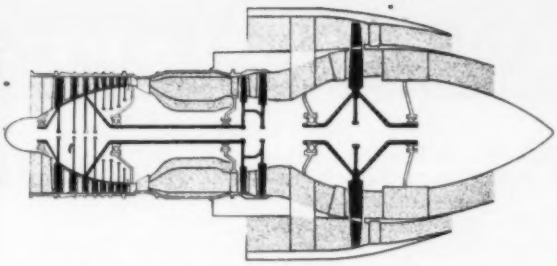


Fig. 13. Smallest double-flow engine currently in advanced development, the General Electric CF-700-1 is based upon the J85 turbojet

TURBOFANS . . .

A turboprop propulsion system would have provided more range or more cargo and better take-off performance. The turbofan provided greater speed, and take-off performance comparable to current jet aircraft. The productivities in terms of ton-knots per pound of airframe are almost identical for airplanes powered by turboprops or turbofans at extreme range."

While d.o.c. for the fan aircraft were slightly higher, the increased cost was more than justified by its greater cruising speed. In any case, outside the Soviet Union there is no turboprop large enough on the right time-scale, so Douglas could even be making a virtue out of necessity.

Smallest of the Pratt & Whitney fans would be a derivative of the single-shaft JT12. The company have made no reference to such a project, but the American technical Press state that it exists on paper, and would weigh about 600 lb and have a dry thrust of some 4,000 lb. Of more immediate importance is the JTF10A (Fig. 12), which has been selected by Douglas as the powerplant of the projected DC-9. Compared with its progenitor, the J52 turbojet, the JTF10A has two fan stages replacing the first three of the nine stages originally fitted to the low-pressure spool, and, as in the case of its larger stablemates, the second stage of the l-p. turbine has been replaced by two new stages.

Like the other Pratt & Whitney engines, the C/H ratio is 1.5 and in the DC-9 this is matched to a cruising speed of some 550 m.p.h. The unit will be installed in the DC-9 with a by-pass duct taking the cold flow to a combined propulsive nozzle to the rear of the nacelle. Complete thrust reverse will be incorporated. Pratt & Whitney are, however, prepared to build a Boeing-type pod, discharging the cold flow on either side. Development of the JTF10A is being financed entirely by Pratt & Whitney. For this reason, and also to minimize the purchase price of the engine and compress its development schedule, the maximum possible utilization is being made of design principles and actual hardware already proven with other engines.

In the same manner G.E. have produced a fan version of the little J85 turbojet. Developed by the company's Small Aircraft Engine Department, this extremely attractive turbofan, designated CF-700-1, is aimed at a wide range of light military and commercial aircraft. As shown in Fig. 13, the basic J85 turbojet is retained almost unchanged to form the gas generator. Behind has been added an aft-fan assembly which is proportionately much larger than that of the CJ-805. Already some 8,000 hr (mainly on the bench) has been logged on J85s, and G.E. are programming flight-cleared CF-700s for mid-1961. An unofficial report also speaks of a CJ-810, a scaled-down CJ-805-23.

Another possible progenitor of a transport-category double-flow unit is found with de Havilland Engines. The Gyron is a very large turbojet intended for supersonic cruising, and is thus hardly amenable to slow-speed fan applications except for truly giant aircraft. The two-fifths-scale Gyron Junior, however, is singularly light and efficient, and in its later versions with a zero-stage could form the basis for a most attractive fan engine with a rating of around 18,000 lb dry. The company's technical agreement with G.E. would make the evolution of an aft-fan Gyron Junior a relatively simple matter, and the resulting unit could undoubtedly be made very competitive at an early date.

Earlier it was recalled that the first company actually to fly a double-flow engine was the French Société Turboméca. The company's interest in such powerplants has by no means been extinguished, and at the Paris Salon in June it was announced that Turboméca are in an advanced stage of development with a completely new *moteur double fluxe*. This will be introduced next year; some data are given in the table.

In conclusion, it is pertinent to comment briefly upon the difficulty experienced by practically all engine manufacturers with regard to finance. In years gone by, transport aircraft were invariably powered by engines which were substantially identical to those manufactured in large numbers for military aircraft. Since 1950, the two classes of aeroplane have tended to follow divergent paths, and today certain factors are making the financing of engine-programmes critical. Summarized these are: the fact that development of a new engine is becoming increasingly costly; development is only rarely underwritten by the Government (in Britain and the U.S.A. at least); the total number of engines likely to be ordered is today measured in dozens rather than in thousands; and competition between manufacturers is exceedingly acute, both from the viewpoints of technical quality and price.

Without some assistance—and assuming that the airlines' quality-competition persists—the position is fast becoming ludicrous. The new families of double-flow engines hold out a promise of jet speed and comfort allied with cheaper transportation for all. Yet the need to depreciate these expensive powerplants over a relatively short working life inevitably tends to nullify the advantages which should accrue from their reduced specific consumption. At present the situation threatens to become a vicious circle, in which one has to run furiously to stay in the same place.

DOUBLE-FLOW ENGINES

Type	Max. sea-level rating[1] (lb) and r.p.m.	Cruise rating[2] (lb)	Cruise s.f.c.	C/H ratio	Max. diam. (in)	Basic length (in)	Weight[3] (lb)	Applications and orders (italic=options) *=military	First run	Cert'n. date	Prod'n. engines available
BE.58	14,500/ —	3,750	0.80	1.5–2	46.5	123	2,600	Bristol 205 (project) ... / VC.11? (project)	59[4]	—	—
CF-700-1 ...	4,000/ —	1,020	0.97	1.5+	33	69	585	T-39* and others ...	59	Early 62	—
CJ-805-23 ...	16,100/7,680	—	—	1.56	53	144	3,825	CV-600 (32, 31)	57	April 60	—
CJ-810-1 ...	8,000/ —	—	—	—	—	—	—		project	—	—
JT3D-1	17,000/8,200	4,000	0.79	1.4	53.05	145	4,025	Boeing 707-120B, 720B (50) / DC-8 (5) ... ... / B-52H* (70)	58	—	July 60
JT4D-1	25,000[5]/8,000	—	—	1.5	62.4	146	5,700+	Douglas CX (project) ...	project	—	—
JT4D-3	22,500/8,000	—	—	0.8	52.9	141	5,450		project	—	—
JT10A-1 ...	8,250/ —	—	—	1.5	38	128.4	2,110	DC-9 (project)	Dec. 59	July 62	—
Conway RCo.12	17,500[6]/9,980	4,625	0.900	0.3	42.2	135.9	4,543	Boeing 707-420 (24) ... / DC-8 (10)	Aug. 58[7]	Dec. 58	Early 59
Conway RCo.15	18,500[6]/9,895	5,040	0.864	0.3	42.2	135.9	4,582	Boeing 707 ... ... / DC-8	May 59[7]	—	Late 60
Conway RCo.42	20,250[6]/9,955	n.r.	n.r.[8]	0.6	45	144	5,001	VC.10 (35, 20)	—	—	Late 61
RB.141-3 ...	13,790[6]/9,750	3,940	0.814	0.7	41.3	130	3,560	Caravelle 7 (project) ...	Nov. 59	—	Mar. 62
RB.163	9,850[6]/n.r.	—	—	—	—	—	—	Airco D.H.121 (24) ...	—	—	Dec. 62
Turboméca ...	1,700[9]	398[10]	—	—	—	—	—		60	—	—

Notes: 1, ICAN, static, dry (except where suffix 5); 2, ICAN, 36,000ft, 500 kt; 3, basic dry, ready to run; 4, run as military BE.53; 5, wet rating; 6, guaranteed minimum figures; 7, first 150-hr test (first run cannot be determined since each is outgrowth of earlier family); 8, cruise s.f.c. is classified, but sea-level max-thrust s.f.c. is 0.655, compared with 0.745 for RCo.12; 9, s.f.c., 0.59 (sea-level cruise will be 1,235 lb with s.f.c. of 0.57); 10, thrust is 419 lb at 29,500ft with s.f.c. of 0.88; n.r., not releasable

Straight and Level

NOTHING makes one so unpopular as disillusioning people. So this may make me very unpopular indeed; because if what I say is true (and I'm pretty sure it is) it's going to kill a great British tradition stone dead.

It's about the Fox: Fairey's crowning achievement . . . one of the most famous and significant of all British aircraft . . . the machine which set new standards of performance . . . the bomber that was faster than contemporary fighters. . . . You know.

Of course, the Fox was a magnificent aeroplane. But it simply was not any of those things that people love to think about it. Or not many of them, anyway.

In the first place, it wasn't really British at all. It had an American engine, an American propeller, an American cooling system, and was designed according to American precepts. The designer was a Belgian (the one who put the M.L. in M.L. Aviation), and the flight observer was a Belgian too (the one who put the Tips in Tipsy). The test pilot, Norman Macmillan, I'm happy to report, was, and remains, a good Scot.

* * *

As for the Fox being faster than contemporary fighters, it's true that it could get away from the whiskery Siskins and Gamecocks then in service. But Fairey's own Firefly, built in the same year, was at least 30 m.p.h. faster. Anyway, the D.H.4 bomber of 1916 was swifter than most fighters of its day (I call on J. M. Bruce to witness).

But it doesn't really matter. What *does* matter is that Fairey's Rotodyne is original, unique, unchallenged and, incidentally, one hundred per cent British.

● It is wonderful what can be achieved by an Order in Council. With one stroke of an official pen a powerful Ministry is swept away, and those who lived and moved and had their being inside its offices suddenly find themselves pedalling on air.

But all is well. What we witness is merely a gigantic transformation scene; the stage revolves, and there in place of the Ministry of Supply and the Ministry of Civil Aviation is the Ministry of Aviation. And with the disappearance of the initials M.o.S. may disappear many of the things for which they once stood—"cushy" contracts, drifting target-dates, slack commercial discipline, and so on.

"M.o.A." is a refreshing change of initials, which may come to stand for a revitalized industry.

● That enterprising firm Thinx Electronics Ltd., lead by dynamic chain-smoking Sir Harold Digit-Smith, announce the appointment of an INITIALS Manager.

His job will be to devise for the firm's products "spontaneous and natural names, the individual initials of which are also spontaneous and natural."

Here are a few examples of the names he has given to three of Thinx's better-known products:—

B.E.D.S.T.E.A.D. (*Reading Simulator*)—Busy Executives' Device for Sifting Through Endless Aviation Documents.

S.A.D.I.S.T. (*Air Trumpet*)—System for Absolutely Deafening Intractable customers with Sales Talk.

E.A.R.W.I.G. (*Meeting Simulator*)—Executives Assembled Remotely Without Interdepartmental Gibberish.

● Bequeathed unto Mr. Sandys by Mr. Watkinson was one of the oddest bits of "policy" ever propounded by a minister responsible for civil aviation.

It was this: When economy-class services are introduced by B.O.A.C. on the African routes, the independent airlines should be allowed 30 per cent of the business with B.O.A.C. having the remaining 70 per cent. Whether one's view is that the independents should have 100 per cent or zero per cent, I think it must be agreed that such an arbitrary division will be quite unworkable in practice.

Who determines what shall be 100 per cent? Or, supposing there are 10 services a week to start with, if Hunting-Clan or Airwork want to increase their flights from three to five, would B.O.A.C. agree to put on another 4½ flights a week? If they refused, they would be accused of being dogs-in-the-manger. If they accepted, they might lose millions.

* * *

One can visualize many such conflicts—and dodges. Like, for instance, the formation of special associated companies to operate services under a different name. And I suppose B.O.A.C. *could* let its partners E.A.A.C., S.A.A., C.A.A., Nigerian Airways and Ghana Airways operate all its economy services, doing a token 2½ services a year itself, leaving Hunting-Clan and Airwork with one service a year between them! Absurd, but an illustration of the loopholes.

Mr. Sandys might quietly abolish his predecessor's 30-70 policy, and replace it with a more expansionist policy. On the routes from the U.K. to Africa, on which B.O.A.C. and its pool partners are exposed to little foreign competition, why not let a selected independent—as the French do—compete freely and on level terms? If the independent succeeds, and B.O.A.C. suffers, the situation should be reviewed. If, however, the independent fails there should be no complaints from anyone.

● A new "electronic supervising system," made by the Aga Dictating Machine Company, was recently installed in Air France's London reservations offices in Bond Street. Here is an extract from the handout:—

"The system enables the manager of the reservation department to listen-in on any conversation between clerk and client and to record it. The recording can subsequently be played back to the clerk and the manager can then point out how he could have improved his handling of the call."

The reaction of Air France's reservation staff might well be *"Grand Frère nous écoute."*

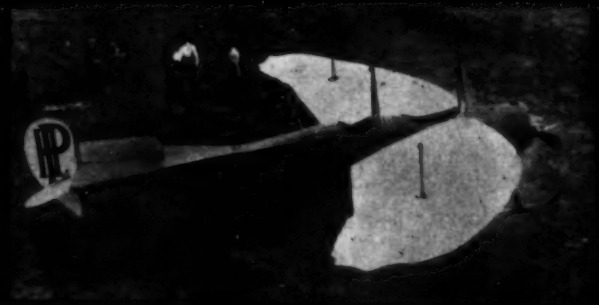
ROGER BACON

ESCARGOTS A LA CARAVELLE

Nice, Oct 21, Reuter.—A Caravelle jet airliner skidded "as if it were on ice" as it landed at the airport here last night on a runway covered with thousands of snails. . . .

Her name is Ginger, and she is a golden retriever who was despatched by her master on a Seaboard and Western flight from Paris to New York. When she arrived it was discovered that four more passengers had been added to the list

Frederick Handley Page, portrayed in a "Flight" photograph of 1913, and the Handley Page monoplane constructed in 1910



BLUEBIRD TO VICTOR

JUBILEE YEAR OF HANDLEY PAGE

ON June 17, 1909, Frederick Handley Page founded the organization which bears his name today. Handley Page Ltd. was the first company to be constituted exclusively for the design and manufacture of aeroplanes. Several types of aircraft were constructed at the company's Barking works, some to customers' own designs, others the exclusive products of "H.P." Early interest was shown in wings of crescent form with a view to procuring inherent stability, and the first machine to incorporate this feature was the Bluebird of 1909. The company's first real success was with a 50 h.p. monoplane which flew in 1910.

In 1912 the company moved to larger works at Cricklewood, and there the first aircraft (five B.E.2s) were built to a Government contract. For most of its existence the company has been principally identified with large bombers and transports, and the first of the big bombers was the O/100, which flew in 1915. It had a span of over 100ft and was the forerunner of the even more renowned O/400. Since those days the R.A.F. has never been without a big Handley Page aircraft in its service. In 1916 an O/100 created a record by carrying 20 passengers and pilot, and in 1919 the huge V/1500 four-engined bomber carried 40 passengers. Machines of the V/1500 type were ready to bomb Berlin from British bases when the war ended.

From bombers it was a logical step to civil transports, and Handley Page Transport Ltd. was formed in June 1919 to operate converted O/400s on pioneer overseas routes. A London - Paris service was begun in August 1919 and was followed by passenger and freight services to Brussels, Amsterdam and Basle. From 1920 onwards the converted military Handley Pages were replaced by a series of large civil biplanes, beginning with the W/8 12-seater, a type which gained the highest award in the Air Ministry competitions of 1920. In 1924 the identity of Handley Page Transport Ltd. was merged with that of Imperial Airways.

The company considers today that the Handley Page slotted wing, invented in 1919, ranks in importance with its development of large aircraft. This invention was patented in many parts of the world and assumed many forms.

Entirely new standards of luxury and reliability were set by the fleet of Hannibal/Heracles biplanes (H.P.42), the first of which flew in 1930. A fleet of eight operated by Imperial Airways aggregated some 12,000 hours' flying apiece and carried about half a million passengers without injury to one of them. These aircraft saw active service when war came in 1939.

In the early 1930s a new airfield was constructed at Radlett, and from that base flew the Hyderabad, Hinaidi and Heyford bombers for the R.A.F. These were followed by the Harrow, a big monoplane bomber, and later by the all-metal Hampden, which introduced new production techniques.

Twenty-four years after the first big Handley Page aircraft had been built came the Halifax, one of the truly great aircraft of the Second World War. More than 6,000 of this type were built. At peak production the Halifax construction group comprised 41 factories and dispersal units, 600 sub-contractors and 51,000 employees. At one time a complete Halifax was being produced every working hour.

A post-war military transport was the Hastings—still rendering exemplary service—and this had a developed civil counterpart which is also operating today as the Hermes.

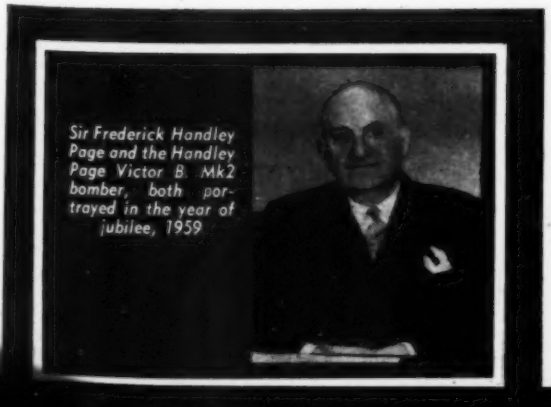
The Handley Page bomber tradition is perpetuated and enhanced by the Victor four-jet crescent-wing bomber, the development and technical characteristics of which are dealt with at length in subsequent pages. Victor B.2 production is now going forward, while the Dart Herald branchliner maintains the name of Handley Page in civil aviation.

For several years H.P. research has been directed towards boundary-layer control, and the H.P.113 project is a small jet transport embodying this technique to an unprecedented degree. Unofficial mention has also been made of a new Handley Page research aircraft to aid in the investigation of the problems of flying supersonic airliners.

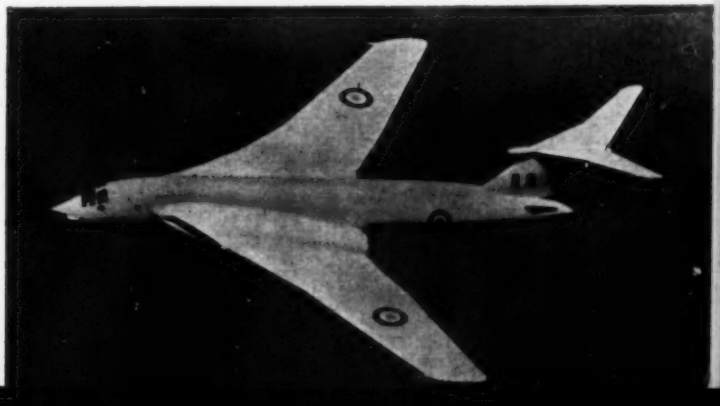
As we remarked at the outset, the company was founded on June 17, 1909, and 50 years later to the day a dinner in celebration of the anniversary was given by the company in London. It was a memorable occasion in every respect and our report, publication of which was prevented at the time by printing difficulties, is now rendered as a valuable contribution to Handley Page history.

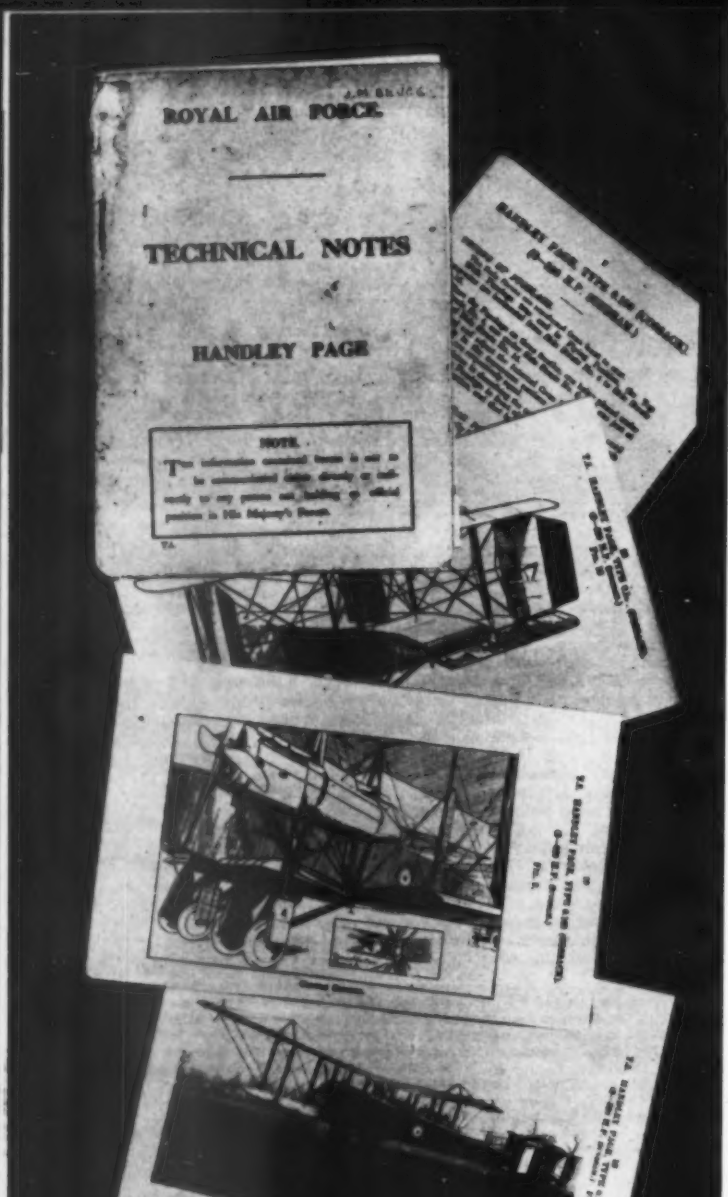
Deputizing for the Minister of Transport and Civil Aviation, the Minister of Power, Lord Mills, proposed "The Oldest Aircraft Company" and referred to the Oxford Dictionary definition of "Handley Page" as "a type of large aeroplane." He recalled that Lord Douglas had been chief pilot of the air transport company founded by Handley Page in 1919.

The toast was seconded by the Secretary of State for Air, Mr. George Ward, who paid a tribute on behalf of the Air Council. The privilege, he said, was the greater because for a short time he had served as a humble apprentice at Handley Page's Cricklewood works—when the first of the Hannibals was being built. Mr. Ward drew the attention of his listeners to an ensign that had been carried by an aircraft of the first 0/400 squadron operated by the R.N.A.S. in France. [Now framed and carefully preserved, this historic flag has been battered by slipstream and ravaged by time.] Mr. Ward also reminded the company that the V/1500 of the First World War was a bigger aircraft than the largest R.A.F. bombers of today. Such aircraft as this were the forerunners of the Hyderabad of 1926, from which year, until now, there had always been a Handley Page bomber in squadron service with the R.A.F.—and often a transport version in parallel. The R.A.F.'s first operational sortie in World War II was made by a Hampden, as was the first bombing attack on enemy territory. Over 6,000 Halifaxes had been built, in 26 major variants. In Bomber Command alone there had been 35 Halifax squadrons, and at one time one Halifax was coming off the line every hour of the day. The Secretary of State went on to praise the Hastings as "a versatile and rugged aircraft" which had been in service for eleven years. Over 138,000 parachute descents had been made from these machines and not one passenger had been killed in them. When the Hastings was first needed to perform the heavy-dropping role a gun was slung underneath it, and this spectacle had given rise to the remark that the camel was really a racehorse that had been built to Air Ministry specification. The Victor was un-



Sir Frederick Handley Page and the Handley Page Victor B. Mk2 bomber, both portrayed in the year of jubilee, 1959





BLUEBIRD TO VICTOR . . .

doubtedly one of the finest strategic bombers. Handley Page had always made a particular feature of research and development, and Mr. Ward mentioned in particular the slot, laminar-flow, boundary-layer suction and the crescent wing. The people of the whole free world, said Mr. Ward, were greatly indebted to Sir Frederick—and he had given to public work the same effort as he had applied to his business.

Responding, Sir Frederick said that the company might be old, but it was not suffering from senile decay. It was, in fact, at the apostolic stage—and Sir Frederick did not disappoint his listeners by omitting a biblical quotation. "Come over to Macedonia and help us," he cried to prospective customers. "We will give you impartial advice."

Aviation today, Sir Frederick declared, was too noisy and too expensive. We did not want to search after supersonics if we were going to get big markets. Aircraft must get cheaper—although here, he said, he was alluding to increased economy on the part of operators and not a reduction in price by the manufacturer. He looked ahead to the day when the whole of the world would be mapped out, for the purpose of air travel, as on squared paper, and when aircraft movements would be dependent on radio and radar.

Sir Frederick went on to make generous references to famous aircraft

These pages from the Technical Notes on the first H.P. bomber may be contrasted with the Victor description in the following pages

by other British manufacturers—the Sopwith Baby, Avro 504K and Vickers Vimy. His own company, he said, had made *big* aircraft, although Holt Thomas of the Aircraft Manufacturing Company had told him that what was needed for civil purposes was a small, fast aircraft flying at 130 m.p.h.—not 100 m.p.h., as were his own machines. Sir Frederick also alluded to Claude Grahame-White, who had exploited flying at Hendon. "We are apt to forget these people who laid the foundations of aviation in this country," he said.

He had sometimes been asked what was the best thing that had happened to him in his life in aviation. It was, he declared, an advance of £20,000 in gold from the Admiralty in 1915. That sum had been forthcoming through the offices of Winston Churchill, who wanted "a big land cruiser, flying at 3,000ft, and armoured so that it could sail through the defences and drop its bombs." "Who am I," asked Sir Frederick, "to stop a great ideal when someone offers to lend me £20,000?"

We would not be successful in the civil air markets, he went on to declare, unless we made something like the Morris Minor in the car world and less like the Maserati or B.R.M. or Vanwall. The populace of the world would travel in greater numbers; and it was hardly necessary to tell his audience the type of aircraft needed. Colleagues would give out brochures.

Sir Frederick obviously derived great enjoyment from describing the growth of various forms of transport, particularly that of the railway train, which, he said, had not changed in the past hundred years. Trains, like other forms of land transport, would have to get down lower to the ground. The aeroplane had taken the propeller from the ship, and an aircraft that flew with a propeller or heated jet made a lot of noise. This power could be used to stop turbulence and lessen noise.

Sir Frederick acknowledged his indebtedness to "a lot of good friends," and he named at random Messrs. Russell, Stafford, Manley Walker, Collard, Green and MacRostie. He added the warning that we must in future give extra technical training. We had to produce new inventions and discoveries or we had no future. He concluded: "With malice toward none, with charity for all, we pursue our course."

History—by the C.A.S.

Proposing "Pioneers of Aviation," the Chief of the Air Staff, Sir Dermot Boyle, said that strict security regulations at Handley Page had prevented his getting a list of guests. So he felt like the cannibal chief who, voyaging on the *Queen Mary*, and being presented with the menu, remarked, "This is no good to me. What I want is the passenger list."

Sir Dermot reminded the assembly that aviation *did* exist before H.P.; and he went on to allude to what he termed the "B.H.P." period. Sir Dermot amused and instructed his audience by referring to certain important dates in aeronautical history, beginning with 1783 (first flight by a man). To the year 1885 he ascribed a remarkable flight by a certain device (no doubt equipped with slots and flaps) which was "the stork that brought Freddie Handley Page to his mother."

Having carried his historical survey nearer the present, Sir Dermot alluded to the nuclear deterrent which had preserved peace for ten years, and to the Comet of Transport Command—an aircraft which he said was outstanding in every way. He wished the R.A.F. had more.

"It is rather easier to put ourselves in orbit round the moon," Sir Dermot said, "than to go to Australia." He would like to see people concentrate on going quickly to Australia. He was told that this could be done in 52 min 42 sec. It meant rising and flying for two minutes, going into orbit for about five minutes, and spending the remaining forty minutes or so slowing down to land.

Sir Dermot coupled with his toast the name of Lord Brabazon. "What a wonderful spirit his book engenders," he said. "It is the most inspiring I have read."

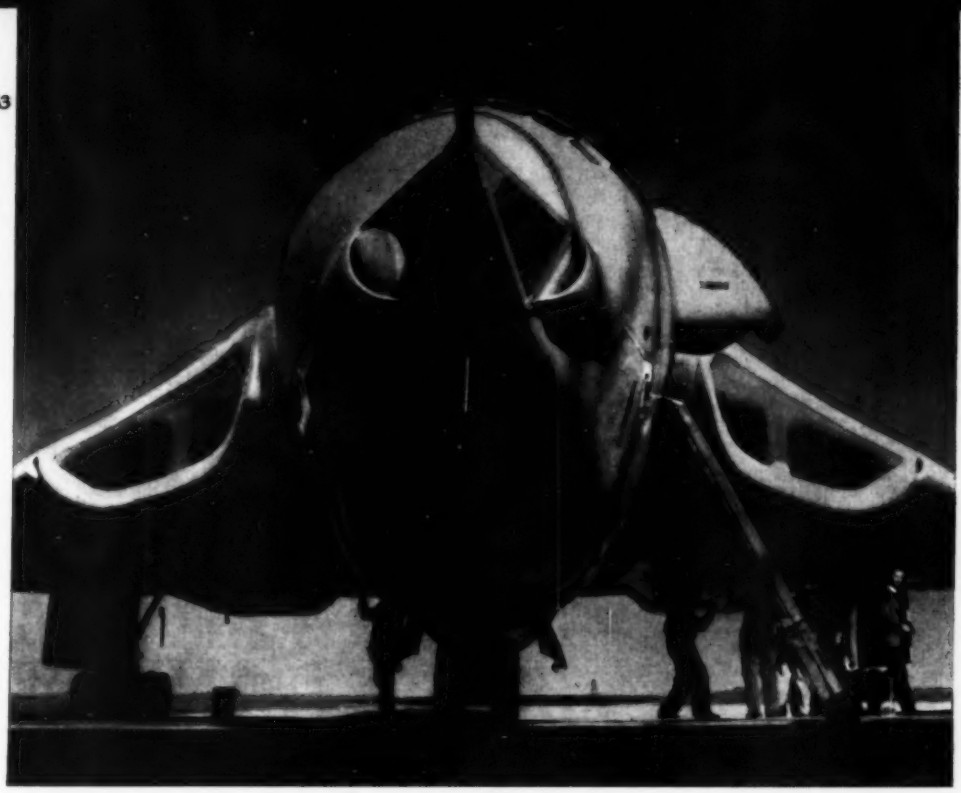
Responding, Lord Brabazon of Tara said that he was getting to the age where he was called "sir." He loathed it. Also he was dragged up at dinners as a sort of human pterodactyl. "It may come as a surprise when you look at me," he said, "to learn that I did not know Leonardo da Vinci." Nor, he added, did he know Sir George Cayley; and he went on to refer to a letter from Stringfellow to Cayley proposing a steam-driven engine to carry twenty people. Cayley declared that before flight was safe a hundred necks would be broken. "And the damn things are not safe yet," Lord Brabazon remarked.

He himself had known the Wrights very well. He adored Wilbur, who was for a long time in this country. He believed that Wilbur liked us. He described as "a strange story" the sojourn of "that great first piece of carpentry (the Wright aeroplane) in the Science Museum for 25 years." Lord Brabazon had sometimes been asked why Wilbur Wright did not cross the Channel before Blériot. Even before the end of 1908 he had flown for 2¼ hours. Lord Brabazon believed the explanation was that Wilbur was a very cautious man, and that he never appreciated the significance of the crossing. To him it would have been like crossing the River Missouri.

Lord Brabazon went on to recall the air communities at Sheppey, Hendon and Brooklands. He himself had belonged to Sheppey. All the early pioneers, he said, were quaint people and a bit mad. It was only necessary to look at H.P. and himself to confirm this.

Lord Brabazon recalled having talked with Wilbur Wright of aeroplanes that might travel at 100 m.p.h.; but transatlantic flying was not even thought about. With evident emotion he alluded to the "mystery and miracle" of flying. He himself had never had anything to do with the firm of Handley Page, but he had had much to do with H.P. himself, particularly as the two had come to be regarded as professional back-chat artists. It had been a lot of fun. Sir Frederick, he said, had got a lot out of aviation; but he had put back even more than he had taken out.

Lord Brabazon concluded, "He always was, and is, a very great man."



VICTOR

A TECHNICAL DESCRIPTION OF BRITAIN'S LATEST V-BOMBER

WHAT follows is perhaps the most elaborate description of a modern airframe which we have yet published. The subject is the Handley Page Victor bomber, and the text refers specifically to the Mk 2 version, differences from the Mk 1 being noted where they occur. Owing to security considerations little can be said about the electronics, fuel system and military equipment. Previous articles on the Victor include "The Crescent Wing" ("Flight," January 9, 1953) and "Parade of Victors" ("Flight," September 19, 1958).

IN 1945 a technical team composed of representatives from the aircraft industry and Ministry of Aircraft Production visited Germany to study that country's work on swept wing and tailless aeroplanes. Included in the team was Mr. G. H. Lee, now deputy chief designer of Handley Page Ltd. In the following year his company made a proposal to the Air Ministry for a swept-wing four-jet bomber. The evidence from Germany upon sweep-back, both plain and compound, had inspired the Cricklewood designers to consolidate their previous schemes for a tailless jet bomber into a design with a tailplane and a swept wing of high aspect ratio having wing-tip rudders. This project was planned round four 6,500 lb Rolls-Royce AJ.65 engines and was to have had a gross weight of 90,000 lb; the span was 122ft and the length 92ft, and with a bomb load of 10,000 lb it was estimated to have a still-air range of 5,000 statute miles at 520 m.p.h. at 50,000ft. The original specification of the V-bombers is still classified secret, but has been generally rumoured to have a similar level of performance. It was issued on January 1, 1947.

Such a specification posed a formidable challenge, and it was met by attacking the problems with two teams, under the co-ordinating control of Mr. R. S. Stafford (now technical director); these teams comprised an airframe and systems group under Mr. C. F. Joy (now chief designer) and an aerodynamic one under Mr. Lee.

The original layout was, in the natural course of design (i.e., compromise) to lose its wing-tip vertical surfaces, grow a full tail and become increasingly crescent-shaped in plan-form. By January 1948, the cut-and-thrust of performance and possibility had evolved the H.P. 80s with a three-stage crescent mid-wing, leading-edge flaps outboard, a cylindrical fuselage and mid-high tailplane. At this stage a design contract was awarded by the M.o.S., and four 7,500 lb Metrovick F.9 axials (progenitor of the Sapphire) were chosen. By the following year the tailplane had been raised and the final design became substantially as we know the Victor today—or at least as the prototype B.1 WB771, which flew on Christmas Eve 1952—and two prototypes with Armstrong Siddeley Sapphires were ordered. The production contract was placed late in 1952.

During the early development of the final layout the proportions of the crescent sections were modified in conformity with tunnel results. It was also at this stage that dihedral was added to the tail to increase the effective fin area. Apart from a lengthened fuselage and a slight change in fin area, the production Mk 1, with the 11,000 lb Sapphire ASSa.7, is essentially similar.

Blackburn and General Aircraft, under contract from Handley Page, used an Attacker fuselage as the basis for a research aircraft with a crescent wing (to the original proportions) and a high tail; it was then designated H.P.88 but the aircraft crashed in 1951 before very much had been learned from it. Another setback in development was the loss of the first prototype Victor in a low-level run at Cranfield on July 14, 1954, as a result of tail flutter.

The second prototype WB775 flew on September 11, 1954, and the first production B.1 XA917 followed on February 1, 1956. In June 1957 a speed slightly in excess of Mach 1 was reached in a shallow dive. Deliveries to No. 2 O.C.U. began in November 1957 and the first aircraft were in operational service by the spring of last year. (A report in *Flight* for September 19, 1958, stated: "No. 10 Sqn. is at full strength, No. 232 O.C.U. at Gaydon is training crews, No. 15 Sqn. is forming, and some Victors have already joined a reconnaissance unit at Wyton.") The Victor B.Mk 2 made its first flight on February 20 of this year. The installation of Rolls-Royce Conways (almost three times the thrust of the original Sapphires) has necessitated larger intakes, and 10ft has been added to the span to match the thrust and raise the operational ceiling; but otherwise the original design remains unaltered in all its essential features.

Aerodynamic Design

In all aeroplanes the efficiency of performance is primarily dependent upon wing design, and where long range is required the wing is paramount. The designer of a bomber has an advantage over the designer of an airliner because he has a far less demanding payload. Even a megaton store and its associated services is as nothing compared with the drag of a passenger fuselage.

The first design objective for the Victor was to evolve an envelope with a constant critical Mach number over its entire surface. That is to say, the curvatures which locally accelerate the airflow to the point where the shockwave drag rises sharply

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must be carefully matched over the whole aeroplane, the fuselage and tail equally with the wing.

Nevertheless, it is the wing which is the crux of the problem, for it is from the correct design of this element that the high L/D essential for range is obtained. The wave-drag rise at high subsonic speeds can be suppressed either by low thickness/chord ratio or by acute sweepback, while induced drag is kept down by increasing the aspect ratio. Thin wings are heavy, and sweepback leads to instability, particularly as aspect ratio is increased. Superimposed upon this initially complex choice are the problems of strength/weight ratio and even structural practicability.

Three ways of obtaining the necessary L/D for long range at high altitude have been put into practice: the plain, thin swept wing with engine pods; the compound-sweep wing with buried engines; and the tailless delta with both load and engines buried. All three can be made to give the required answer and Mr. Lee has tabulated the pros and cons of the resulting compromises in terms of parasite drag, using the pod design as the reference and postulating equal span and weight.

	Pod	Delta	Crescent
Span	1	1	1
Wing area	1	2.5	1.5
Wing drag	0.33	0.85	0.49
Nacelle drag	0.15	0.02	0.02
Fuselage drag	0.27	0.15	0.25
Remaining drag	0.25	0.18	0.25
Total drag	1.00	1.20	1.01

Upon these generalized figures Mr. Lee commented that, for optimum-range cruising, maximum L/D conditions will be used (i.e., where induced and parasite drag are approximately equal) and therefore, the three types having equal induced drag (because of the equal span and weight) the overall drag of the delta is some 10 per cent higher. The large area of the delta permits the span to be reduced to 90 per cent, but although this reduces parasite drag there would be a compensating rise in induced drag, which would return the same answer.

Commenting upon weight trends, Mr. Lee said, "The podded wing has small thickness and torque-box area but has very good weight-relief due to the engine disposition, small wing area and an unbroken structure. The delta wing has large thickness and torque-box area but small engine weight-relief, much the largest gross area and a high rib weight; from this it would be expected that the delta-wing weight would be the highest. The crescent wing has moderate thickness, moderate torque-box area and moderate wing-surface area, combined with small weight-relief.

"The fuselage weight for the podded aircraft is probably largest because the undercarriage has to be stowed in it. The delta fuselage is probably the lightest because it is a small one.

"Combining all the above tendencies, it may be concluded that none of the layouts appears to have a marked advantage in weight. The crescent and the podded aeroplane have a fairly similar weight-distribution; the delta weight-distribution is different and what it loses on the wing it gains on the fuselage and the tail."

Some of Mr. Lee's concluding remarks on performance comparison are also well worth quoting. Assuming equal critical Mach numbers, then: "The operational heights of the crescent and the delta are both better than that of the podded layout, which suffers from its high wing-loading. This will reduce cruising height and will badly restrict manœuvrability at altitude. The podded aeroplane suffers also from rather bad aeroelastic properties with regard to the manœuvre margin. The take-off and landing performance of the crescent and delta is satisfactory in both cases, and is much better than the podded layout which suffers, again, from its high wing-loading."

Like all wings, the compound-sweep (or crescent) wing is a compromise between lift, drag and stability at low and high speeds but, unlike most compromises, the fact is externally obvious.

The range, high cruising altitude and Mach number of the Victor specification could have been set by a relatively high aspect ratio wing of either low thickness or considerable sweep. Ruled by Mcritt, the maximum allowable depth for a moderate sweep would be too thin structurally at the required aspect ratio. On the other hand, the sweep necessary to achieve the same Mcritt with a practical structural depth at the root entails severe tip-stalling, in turn causing pitch-up instability. Worse still, this instability increases with aspect ratio; whereas 60-deg leading-edge sweep is stable at about 1.5 aspect ratio, at a practical value for range—say between 5 and 6—only some 25 deg of sweep can be used without incurring instability.

The principal reasons why sweepback aggravates tip-stalling are two; load-grading and spanwise flow. Load-grading (i.e., the spanwise distribution of lift) is affected by sweepback, the local C_L being greater at the tips than at the root, so that the tips stall first. As the stall is approached, the increased spanwise drift is caused by the effect upon the streamlines as they enter the rising pressure-gradient over the rear of the wings at an oblique angle. The velocity component parallel with the pressure-gradient is reduced and the flow is thereby deflected in the direction of sweep, the velocity component along this axis being unaffected. The outward drift of the boundary layer is similar in effect to sucking it away over the inner part of the wing, thereby both delaying the stall and reducing the maximum lift coefficient; while at the tip the boundary layer is thickened, so that both maximum lift and the stall are reached more quickly. The greater the aspect ratio the greater the distance for the boundary layer to drift and thicken and also the smaller the tip chord, so that the ill effect is increased.

Owing to their limited camber, and small leading-edge radius, thin aerofoils have poor low-speed, lift and stall characteristics. Slats were considered to pose greater development problems than did leading-edge flaps, which increase camber and follow the shift of the stagnation point at high C_L. Had the Victor been designed a few years later it would have had a drooped leading edge, as has been fitted to the Comet and the Caravelle, or American conical camber. The leading-edge flaps are lowered, in 1 sec, by stored compressed air, owing to the high peak power required; and they can be raised only when the bottles have been recharged. Naturally, they are lowered with the trailing-edge flaps; they lower automatically when the lift coefficient exceeds a predetermined value, sensed by a Kelvin Hughes pressure-ratio switch connected to two holes in the wing and to total-head pressure; and a Mach switch isolates them at high speed.

Aeroelastic Effects

It will be recalled that aeroelastic effects (the interplay of aerodynamic loading and structural distortion) hit the first generation of swept-wing aeroplanes severely. The most serious of these effects is the loss of incidence at the tip as the wing bends upward under load, thus leading to a pitch-up tendency when manœuvring. To maintain a constant incidence during deflection, a swept wing must twist about a rearward flexural axis. It is not easy to design an efficient structure with the flexural axis so far aft, and if the condition is achieved it may introduce flutter troubles and the danger of catastrophic divergence if the flexural/torsional relationship is not exactly correct.*

**Following an idea of the late Professor G. T. R. Hill, such a scheme was designed into the tailless Short Sherpa, in which all-moving wingtips replaced ailerons and elevators and pivoted on the wing flexural axis, were neither subject to reversal nor did they impose twisting forces on the wing. This aeroplane was a model for a reconnaissance project which had to fly fast low down but required a high aspect ratio to achieve long range at high altitude. The basic non-twisting wing is known as "aero-isoclinic."*

Final assembly of the Victor takes place at the company's plant at Radlett, Herts. This photograph shows Mk 1 aircraft on the line. These have 11,000 lb thrust Bristol Siddeley Sapphire engines, some of which are visible in the foreground

Now in widespread use with squadrons of Bomber Command, the Mk 1 Victor differs from the Mk 2 version principally in having less engine thrust and a wing of shorter span. The example depicted in this "Flight" photograph has underwing tanks and a refuelling probe above the nose

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In the crescent wing the flexural axes (the loci of the flexural centres) approximately follow the mean angles of sweep. The load on the outer panels lies ahead of the flexural axis of the centre section, with the result that a favourable twist is developed over the inboard part of the wing, counteracting increase of washout under load. Again, in the rolling plane, the reduction of sweep at the tip is beneficial for aileron reversal, so long as the design embodies normal torsional stiffness.

The fuselage has been designed to the same critical Mach number as the wing. The size of the nose section was dictated by the space required to carry the crew and equipment, especially the radar. It was decided to blend the cockpit with the main cylinder and to allow the radar and equipment to protrude it on the underside, putting the visual bomb-aiming station in the pointed nose, ahead of the radar. The rear fairing of this underbulge provided stowage for the nose undercarriage.

The acute sweep of the wing centre-section brought the spar box so far ahead of the c.g. that it could be accommodated in a mid position, entirely ahead of the bomb bay. As a result, the fuselage diameter could be reduced to 10ft. Although the Victor preceded the area rule, the plot of cross-section is smooth.

From almost every point of view the high-mounted horizontal tail has proved an unqualified success. In the extreme case of pitch-up the surface can pass into wing downwash, but under all normal flight conditions, including the low-speed stall, the tailplane is clear of all wing-generated breakaway. Even at the stall itself buffeting is very mild, and full control is maintained. Interference at the fin junction is minimized, the bullet fairing being required chiefly to fair over structural joints. The horizontal surface acts as an end-plate for the fin and rudder so that, being thereby rendered more effective, their size can be reduced; in fact the production Victors have fins 20in shorter than the prototypes. Obviously, the tail is well clear of jet turbulence and any effect from the ideally situated air brakes.

The fixed tailplane is embryonic, being no more than a mounting for the hinges and a fairing for the elevator power units. The design of the true elevator/tailplane structure confers aeroisoclinic properties and so improves its effectiveness. The large aerodynamic-balance areas reduce hinge moments and thereby the weight of the control-power units, the low-speed overbalance being immaterial with power operation.

Structural Design*

Working closely with the aerodynamic team was the structural and systems design group led by Mr. Joy. This group also worked equally intimately with the production engineers, and communicated decisions to them at the earliest possible moment. While the initial structural design was being investigated, Sir Frederick Handley Page reached the conclusion that manufacturing economy was essential, in order to offer "the best technical job which peace could afford." He reasoned that the contract would go to the company which could produce the simplest, and therefore the cheapest, article. To achieve this end there had to be exceptional co-operation between the design and production engineers.

This occurred at about the time that machined skins were emerging as definite requirements, since it was obvious that the strength/weight capacity of conventionally stiffened skins could be improved upon. An immediate basic investigation was made of low-density materials, and in particular of sandwiches. Much work was done on honeycomb cores, but it was abandoned because the unavailability at that time of a satisfactory adhesive had led to the investigation of a sandwich with a spot-welded corrugated core. As is so often the case in engineering, what was initially the result of *force majeure* led to the evolution of a completely fresh design outlook and a new structural system. The essential difference between honeycomb and corrugated-core sandwich is that the latter, having a directional filling, can take compressive end-loads. When applied in this sense it can result in a better strength/weight-ratio structure than individually lighter honeycomb-skin panels with their necessarily more robust supporting structure. There is, of course, a minimum skin-gauge (below 22 s.w.g.) where the strength/weight curve crosses again, as a result of instability of the unsupported skin areas between corrugations.

There has always been a distrust of welding by British airworthiness authorities, so it was a bold move for a company to pin its faith in a primary structure which was mainly resistance-welded. Nevertheless, after much testing the method was accepted, and economy in works equipment had been achieved, for some half-dozen new Sciaky welders were all that was needed. (Additionally, several new spar millers were also required because of the increased dimensions of the work, but in principle this was routine expansion of plant capacity and not new process equipment.)

A notable feature of the Victor is the number of forgings used. Owing to the relatively short life in flying hours of military aeroplanes it was possible to make the fullest use of the hard (zinc) aluminium alloys without incurring fatigue penalties. The forgings are D.T.D. 683 and the sheet is D.T.D. 687, plus aluminium-copper alloy L.72 and L.73 in the pressure cabin and for secondary parts, as well as magnesium-zirconium castings for control levers and some structural items.

As a result of the stiffness of sandwiches the distortion of aerodynamic surfaces under load is minimized, and there is no residual skin waviness after removal of the load. Quite often with highly loaded skin/stringer structures the secondary material develops a permanent set even when the main members have not been strained beyond their elastic limit. The sandwich stiffness also means that there is no bulging of fuel tanks under internal pressures which can be as high as 7.0 lb/sq in abs. following a rapid climb from tropical conditions (45 deg C) to the stratosphere. Finally, the surface finish, particularly that of the spot-welded skins, is excellent—one would compare it favourably with many machined skins, which often show flats between the stiffening ridges.

Against the sandwich is the argument of the vast number of "fasteners" required—over 500,000 spot-welds in a Victor. It is important to realize, however, that each panel of sandwich consists of three sheets of metal joined by many redundant fastenings.

**The Victor is a very large and complex subject for a single article and it made more confusing by the small, yet often significant differences between the two Marks. The following notes are intended to give a general picture of the aircraft, differences between Mks 1 and 2 being noted only when these are of interest.*

Powerplant of the Victor B.2 is the Rolls-Royce Conway RCo.11 by-pass turbojet of 17,250 lb thrust. These are the most powerful non-afterburning engines in service outside the Soviet Union

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It follows that cracks should occur first in the more highly stressed outer skins, where they are easily detected, and Handley Page fatigue tests prove this. There remains the integrity of the welds, and it is here worth noting that at the 1958 Institution of Production Engineers' aircraft production conference representatives from both Handley Page and Boeing were adamant that there was never any tendency for spot welds to "run like waistcoat buttons" when a part was loaded to destruction.

At Cricklewood many of the outer-skin welds are made with large (15in diam.) wheel electrodes which make a spot barely 0.001in deep; this is amply smooth for high-speed finish and, in fact, the majority of the welds are barely detectable. Where the disc electrode cannot be used, the usual press-type welding machine is used. Quality-control and inspection methods have been described[3] by D. C. Robinson, works superintendent (other references are [3] and [4]):—

"Sheets must be carefully degreased and etched to ensure constant electrical resistance at their surfaces. Thorough tests have given the optimum machine settings for different thicknesses. An inspector checks that the settings are correctly made before a series of welds is begun. Specimens are tested before welding begins and the results plotted on a quality-control chart which indicates any tendency to low strength before it becomes dangerous. Analysis of tests over several years has given design strengths. Statistically, the chance of any weld being less than the design strength is 1,000 to 1 against. Perfect mating of the surfaces to be joined is essential. . . .

"When the process was introduced every spot-weld was examined by X-rays. However, the stringent quality-control technique now employed requires only about 10 per cent of the welds on any panel to be examined. A sampling system is used; welds are chosen at random and X-rayed until sufficient have been examined to decide upon the panel's acceptance or rejection. Panels with 5-per-cent defective welds (of those examined) are rejected in 99 per cent of cases; even those with 2.5-per-cent unsatisfactory welds are usually rejected. Defective panels are not scrapped; additional welds are called for and X-rayed. The spot-welding process is now entirely reliable and, in practice, it is cheaper than riveting if less than 25 per cent of welds are inspected."

The accuracy of mating surfaces required for spot-welding has led to the development, or perfection of, special shop techniques. The large quantities of corrugated core are formed on a brake press with a forming tool that has a contact surface only slightly greater than the bend radius. In this way the surface flatness of the original sheet is retained to promote maximum welding efficiency. There are seven standard sizes of corrugation, which are formed in several gauges in 10ft lengths. Although parallel, constant-depth corrugations are usual, and can be tapered in both width and depth. There are also curved and double-curved panels for which the cores are stretch-formed.

Sandwich panels are made by first fitting the outer skin in a sub-assembly jig, where it is located by very accurate contour templates, and to it the corrugated core is then fitted and service-bolted. After removal from the jig the parts are dismantled, degreased, reassembled and the spot-pitch marked on the skin. The panel is then trundled back and forward through the spot-welding machine. Where there is single curvature across the corrugations the panels are welded flat, being easily handled on roller tables, and the contour fixed in the final assembly jig when the inner skin is fitted and Pop-riveted in place.

Panels with the corrugations across the curve, such as the leading edges, or double-curvature units are more difficult to handle, but the principle remains the same.

Wing. The application of sandwich material to the Victor represents one of the most interesting and ingenious structural pictures one has seen for many years. The aerofoils are, in fact, as inseparable from their structural principle as they are from their unusual aerodynamics.

The inner wing, which incorporates two degrees of sweep, has its primary structure concentrated well forward. Next to the fuselage there are three deep I-section beams, pierced by the dual air-intake duct cut-outs, which, with the sandwich skin, carry virtually all the loads on the wing and transmit them to a boxed triple-web bridge section of the fuselage. In the zone of the intakes torsional stiffness is maintained by the heavily reinforced webs of the I-section beams and the sandwich skins. Outboard of the engine bays there are two heavy ribs, one of which is a sandwich rib, plus an intermediary sandwich diaphragm, which accept the undercarriage loads and diffuse them into the spars and skin.

Placing the engine bays aft of the main load-carrying structure was primarily a precaution against fire or burst-turbine damage, but it also eases maintenance and has simplified the conversion to more powerful engines. In this area, and the adjacent undercarriage bay, the skin panels have chord-wise corrugations, so that the panels will flex freely without picking up endloads from the outer plane. The outer part of the inner plane (incorporating the intermediate sweep/thickness) has a fourth spar-web, which is raked aft to meet the aileron-hinge spar of the outer plane. Thus, there are now three torsion boxes—or a quadruple-web box, depending upon how one looks at it—the skin being of sandwich with corrugations following the spar line.

Inboard, the somewhat drastic removal of material occasioned by the intake cut-outs has been compensated by reinforcing the webs around the opening and incorporating heavy machined spar-boom die forgings. These booms are exceptional, since the ability of the corrugated sandwich to accept compressive endloads means that the torsion-box webs can be lightly capped in the rest of the wing. In the Mk 1 sufficient residual depth was available for the intake cut-out plate webs to be reinforced, but this was impossible for the Mk 2, in which remarkable machined forgings are used. These are D.T.D. 683 billets forged by High Duty Alloys on a 12,000-ton press to give the required grain flow and ductility. Each part emerges as a 3in-thick plate varying in size from 6ft × 5ft 9in to 6ft × 4ft 9in. The stressing problems involved were acute, and so the final design was checked photo-elastically with plastic models, later confirmed by the static tests on the whole wing.

At the junction of the inner and outer wings is both a sweep change and a transport joint. One of the few ribs is located at this station to preserve the integrity of the torsion-box contour of both. It is in fact a twin rib, each with vertical shear corrugations reinforcing a plate web, and pierced for access to the outer-plane tank. The two sections of torsion box are joined peripherally: the front and rear spar webs by crenellated shear fittings and the upper and lower sandwich skins by tension-bolted chord-wise forgings—called "pipe joints" in the works. These peripheral fittings require a spanwise grain-flow, which explains why they are not extrusions but have to be forged by H.D.A. Extensive machining has to be done to form attachment tongues for the sandwich loads and the recessed bolt holes. The way in which the skin and core loads are picked up and diffused by the forgings and fingerplates can be best appreciated from the sketch.

The principle of off-loading the leading and trailing edges by using chordwise corrugations is maintained in the outer plane. There are a few ribs in the outboard torsion box to carry the aileron hinge loads and those from the H. M. Hobson power units. The wing tips, extended on the Mk 2, are more conventional; combining ribs, extension spars and a sandwich skin.

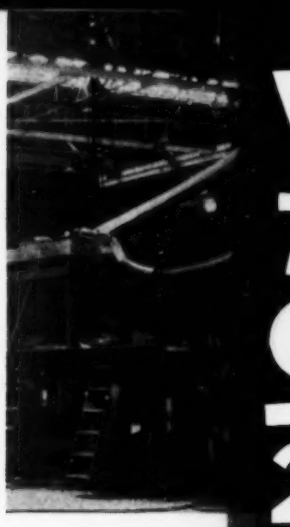
Of particular interest is the large access panel in the under-surface of the wing covering the control power units. Here the corrugated inner skin is chordwise, the spanwise loads being taken in the surface sheet via closely-spaced quick-release fasteners recessed into special dowel and socket units. There is, also, the advantage that the stressed fitting holding the socket can be mass-produced. Dzus fasteners are used at the ends of the panel and Oddie fasteners along the front and rear edges.

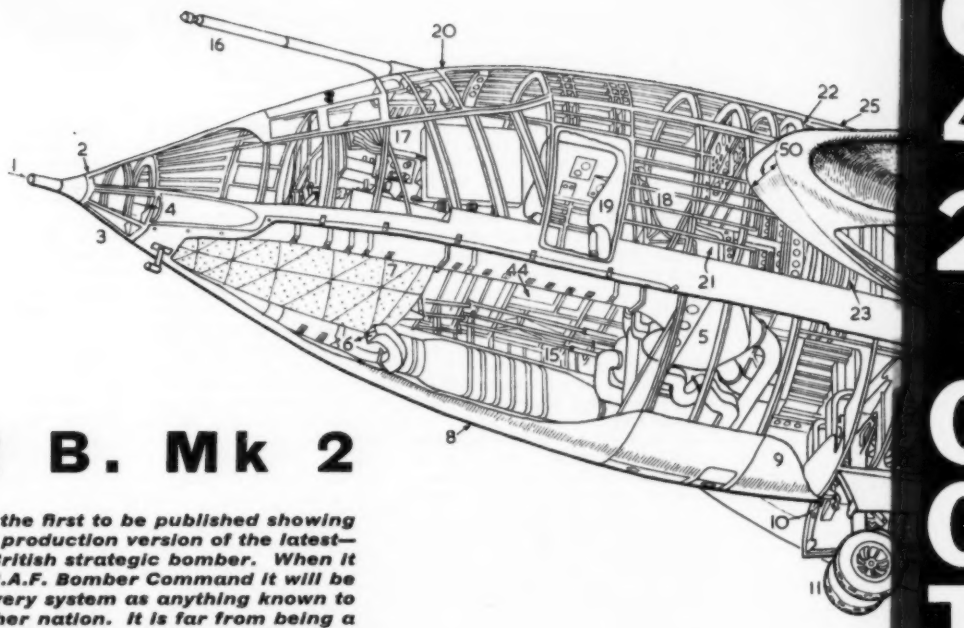
The leading-edge incorporates thermal de-icing, which, as can be seen from the sketch, results in an extra skin being required. The hot air is not channelled through the chordwise corrugations of the leading edge, since this would require a very large mass-flow. The skin unit consists of a thin outer sheet over a thicker sheet milled with accurate chordal grooves, the whole being shaved down near the leading edge. The two skin layers are stiffened by a chordwise-corrugated inner skin mounted, in the case of the nose-flap sections, on spars and riblets.

Mechanically, the nose flaps are novel (see sketch). The actuating mechanism, hydraulic jacks, control valves and electrical relays are supplied as one unit, the pneumatic part of the system pressurizing hydraulic fluid in duplicated accumulators. The flaps are attached by large-diameter pivot pins to forged brackets bolted to the front-spar flanges. The hinge line lies ahead of the spar, and is positioned so that the flaps have an out-and-down action. To maintain contact and a good aerodynamic contour, there is a spring-steel trailing-edge shroud to the flap which, with the aid

(*Continued on reverse of fold-out sheet*)

In the text the construction of the Victor is dealt with at length. The photograph on the left depicts the assembly of a complete tail-plane, the "grain" directions of the various corrugated panels being clearly visible (also illustrated in a drawing overleaf)

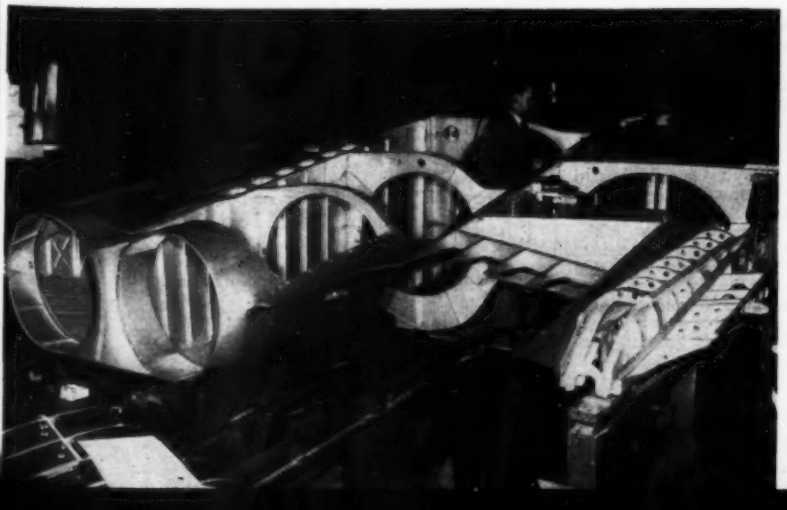




VICTOR B. Mk 2

This drawing is the first to be published showing the current production version of the latest—and possibly last—British strategic bomber. When it goes into service with R.A.F. Bomber Command it will be as potent a delivery system as anything known to be possessed by any other nation. It is far from being a large aeroplane, by any standard, yet it combines sonic speed with very great over-target height, long range and the ability to carry a vast offensive load. Included in the latter may be the Avro Blue Steel stand-off missile

Taking shape in its jig below is a Victor B. Mk 2 inner-wing assembly. This is a starboard inner-wing, and immediately outboard of the powerplant bay may be seen the surprisingly small box into which the Electro-Hydraulics bogie undercarriage retracts



HANDLEY PAGE H.P.80 VICTOR

Basic data for B. Mk 2 (B. Mk 1 in parent

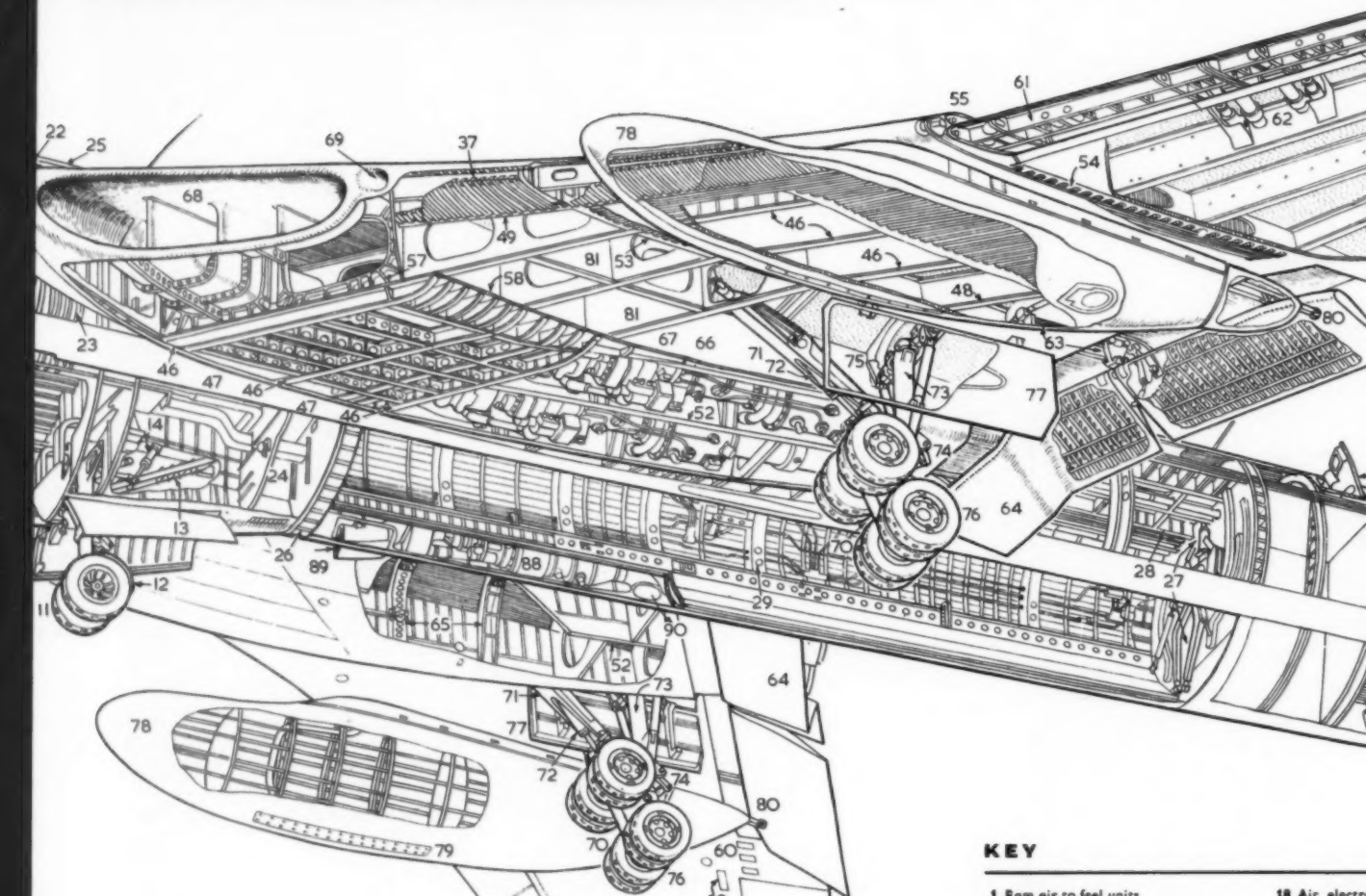
Powerplant: four Rolls-Royce Conway RCo.11 thrust each (four Bristol Siddeley Sapphire 200-ser each).

Dimensions: span, 120ft (110ft); length overa (28ft 1.5in); gross wing area, 2,597 sq ft (2,406 s wheelbase, 24ft 6in; track, 32ft 5in (30ft 2in).

Other data: leading-edge sweep angles, cent 44.3 deg, outer plane 35.2 deg, tailplane 59.6 deg, t/c ratios (per cent), centre plane 16, inner plane 5 elevator 9, fin 10.54 to 11.58; flap angles, trailin 35 deg for landing, leading-edge 20 deg; tyre size 30 × 9.0; undercarriage leg pressure, main 2,50 nominal hydraulic-system pressure 4,000 lb/sq in.

XU

On the left is a centre fuselage and inboard wing of a Victor B. Mk 2 about to start its journey down the assembly line at Radlett. Major airframe portions are constructed at Cricklewood and brought to the assembly plant by road, a journey of some 20 miles. Emphasized by the photograph are the enlarged Conway intake ducts



KEY

1 Ram air to feel units
2 Forged nose ring
3 Bomb aimer's window: dry-air sandwich and warm-air defrosting
4 Twin nostril intakes to air-conditioning system
5 Air-conditioning pack
6 Radar cooling air bleed (off starboard nostril intake)
7 Pressure-bearing floor of prone bombing position
8 Radome
9 "Window" countermeasures launcher-pack position
10 Access to wheel-brake accumulator; nosewheel steering; de-icing tank drains
11 Dunlop 30 × 9in nosewheel tyres
12 Stoneguards
13 Radius rod
14 Retraction jack
15 Flying-control runs
16 Flight refuelling probe
17 Two pilots, side by side
18 Air electr… plotter; b… ward
19 Crew entr… hatch for (
20 Pilots' ej… drogue ass…
21 Navigator'… to stiffen (…
22 Pressure b…
23 Plenum … pressurized…
24 Batteries, … (112V an… refuelling p…
25 Dinghy sto…
26 Bomb-bay …
27 Bomb-door… (each end)
28 Bomb-bay … above
29 Double bo…
30 One of two… tors: intak… r.p.m. belo…

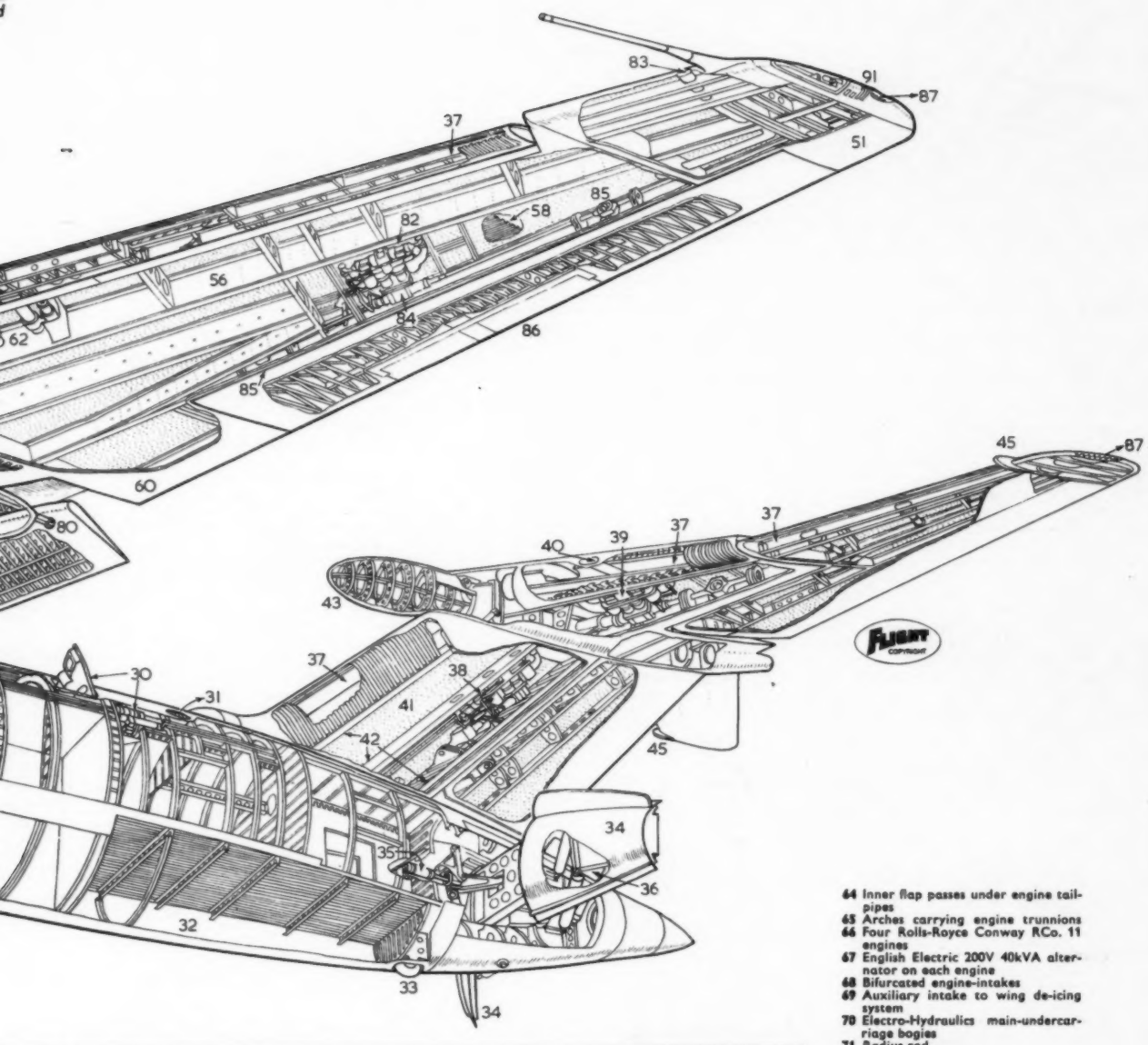
R

) in parentheses where different)

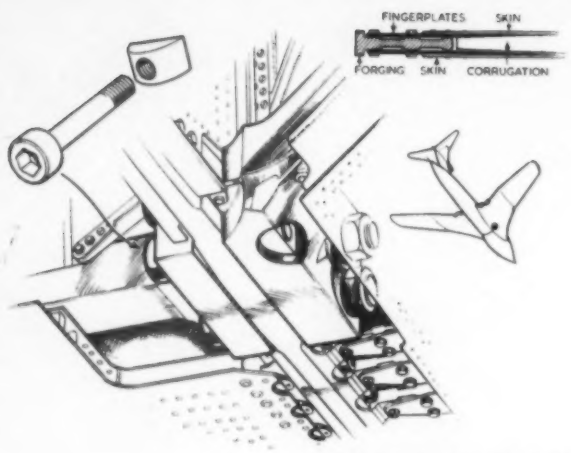
…way RCo.11 by-pass engines, of 17,250 lb …phire 200-series engines, of 11,000 lb thrust …

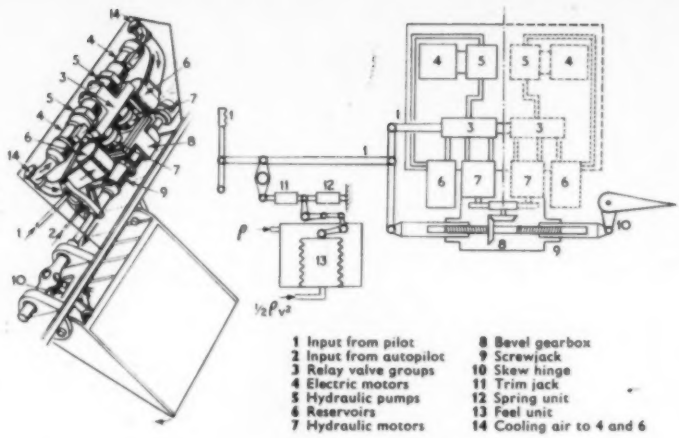
…ength overall, 114ft 11in; height, 30ft 1.5in …q ft (2,406 sq ft); tailplane span, 32ft 8in; …0ft 2in).

…angles, centre plane 52.2 deg, inner plane …ne 59.6 deg, elevator 43.2 deg, fin 48.2 deg; …nner plane 9, outer plane 6, tailplane 12.21, …gles, trailing-edge 15 deg for take-off and …g; tyre sizes, main (16) 27 × 6.5, nose (2) …, main 2,500 lb/sq in, nose 1,000 lb/sq in; …0 lb/sq in.



18 Air electronics officer; navigator-plotter; bomb aimer, facing rearward
19 Crew entry, and shrouded escape hatch for (18)
20 Pilots' ejection escape hatches, drogue assisted
21 Navigator's working top, stressed to stiffen (22)
22 Pressure bulkhead
23 Plenum chamber for ram-air-pressurized equipment
24 Batteries, external electrical sockets (112V and 28V) and pressure refuelling point in this bay
25 Dinghy stowage on top
26 Bomb-bay air deflectors
27 Bomb-door actuator and linkage (each end)
28 Bomb-bay roof beams: fuel cells above
29 Double box-section frames
30 One of two ram-air turbo-alternators: intake extends when engine r.p.m. below minimum
31 Exhaust air from (30)
32 Rear electronics bay and radome
33 Tail bumper
34 Air brakes
35 Air-brake ram on base of fin-box
36 Braking-parachute box
37 Anti-icing hot air duct and milled inner skin (see detail sketch overleaf)
38 Rudder power unit (see detail sketch overleaf)
39 Exactor power unit
40 Cooling air to (39)
41 Corrugated sandwich panels: riveted inner, spot-welded outer skin
42 Three-spar box-structure fin
43 Aerodynamic bullet fairing
44 "Plymax" ply-faced alloy flooring
45 Mass balance
46 Three webs of main box-spar
47 Attachment to carry-through beams in fuselage
48 Fourth spar outboard of undercarriage bay
49 Leading-edge false spar
50 18in centre-section extension over B Mk 1
51 3ft tip extension outboard of aileron
52 Titanium firewall ribs in engine bay
53 Dihedral and sweep decrease outboard of this rib
54 Outer wing multi-bolt joint (see detail sketch)
55 Dihedral and sweep decrease outboard of joint
56 Handley Page aerofoil section
57 Forged spar webs around ducts
58 Spanwise corrugated sandwich
59 Chordwise corrugated sandwich in door area
60 Chordwise corrugated sandwich secondary structure
61 Aerodynamic nose-flap: 23½ deg droop
62 Nose-flap actuators and hydraulic accumulators
63 Flap screwjack: rail and roller assemblies
64 Inner flap passes under engine tailpipes
65 Arches carrying engine trunnions
66 Four Rolls-Royce Conway RCo. 11 engines
67 English Electric 200V 40kVA alternator on each engine
68 Bifurcated engine-intakes
69 Auxiliary intake to wing de-icing system
70 Electro-Hydraulics main-undercarriage bogies
71 Radius rod
72 Retraction jack
73 Main shock-absorber
74 Scissor link
75 Downlock hook and bearing block
76 27 × 6½in tubeless tyres: eight per side
77 Undercarriage doors
78 Underwing tank
79 Access to booster pumps
80 Roller-depressed tank fairing
81 Bag tanks in wing torsion boxes
82 Hobson aileron power unit
83 Cooling air to (82)
84 Gearbox, screwjacks and push-rods to (83)
85 Skew levers
86 Fixed tab
87 Anti-icing air outlet
88 Blackburn Artouste auxiliary power unit driving emergency alternator
89 Retractable intake to (88), and alternator cooling air
90 Artouste exhaust
91 ILS aerial
92 Aileron control-run access panels
93 Stressed access door to (82)





Left, rear view of inner-wing box spar at joint with carry-through beams in fuselage; insets, position of joint (shown by dot); and joint from skins to chordal finger-plates. Right, semi-diagrammatic sketch of a flying-control power unit (the rudder is shown). Full duplication is provided as far as the bevel gearbox (8)

VICTOR . . .

of buttons and guide grooves in the mating wing shroud, forms a close-fitting joint.

The wing-tips, which provide most of the increased span of the Mk 2, have chordwise sandwich (of "Scandinavian type, i.e., outer skin and corrugation only) with spar extension members. Attachment is roughly at the c.p. position, and consists of top and bottom fittings with vertical bolts, one of which is eccentric to provide dihedral adjustment. Adjustable studs at front and rear lock the unit in place and there is a simple rubber-tube seal round the periphery. The leading edge of the tip has a Napier Spraymat de-icing panel.

Altogether the wing is full of fascinating detail engineering, much of which can be appreciated best from the sketches. One would, however, draw attention to some features.

One such detail is the method of joining sandwich panels, using an internal butt strap with shouldered bolts and stepped hole diameters to give automatic spacing. To give scale to the picture, the skins of the sandwich are rather more than an inch apart at the root, falling to less than half an inch, without an inner skin, at the tip. A significant precaution is the placing of sandwich joints along spar and rib centre-lines, the booms of which are themselves formed mainly by backed sections, so that there are crack stoppers along each line of concentrated load. This is but one example of an overall philosophy aimed at achieving adequate fatigue life.

The use of the Scandinavian sandwich is a simple way of tapering off with reduced load and, from the opposite approach, renders cut-out reinforcement simple by adding an inner doubler.

Throughout, exceptional care has been taken to avoid pre-stressing joints in the D.T.D. 683 machined forgings. Hi-shear rivets are extensively used in highly-loaded areas. The assembly of the intake plates on the big centre-plane spar webs contains several ingenious bolting devices that avoid the introduction of compression loading. Torque-loaded spanners are widely used, while the employment of countersunk bolts with Allen hexagon-hole heads is another precaution against overtightening.

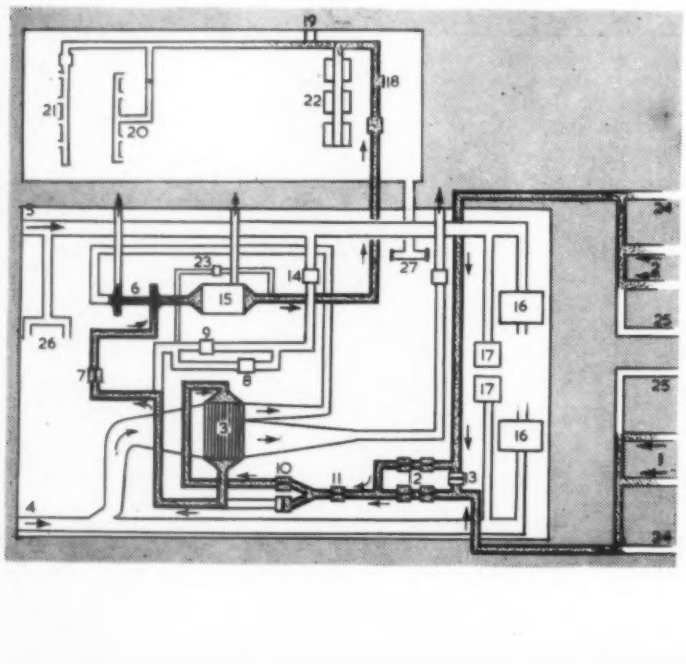
Titanium has been introduced where it shows advantages commensurate with its cost. The metal and its alloys are used for the engine-bay ribs, which are horizontal firewalls and for a number of bolts.

Before leaving the wing one should note that, among the modifications to the root occasioned by the size of the Conway air ducts is a "false bottom" which forms a shallow blister beneath the torsion box. This consists of sandwich skin panels supported on a gridwork of pierced and flanged diaphragms.

Flaps and ailerons of the Mk 1 are of conventional structure, without any use of sandwich, although the Mk 2 aileron skins have corrugated reinforcement.

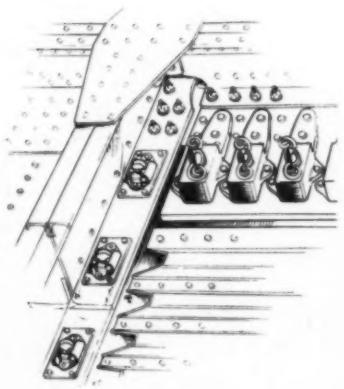
Tail Unit. The fin is a three-web torsion box, in principle structurally similar to the wing. Since it has to be particularly stiff in bending, the leading-edge D-skin and the main skin sandwich have spanwise corrugations. The central spar is a sandwich, while the front and rear ones are plates stiffened against shear angles or their equivalent. De-icing passages are incorporated in the leading edge. The fin is anchored to the fuselage by a forged chordwise pipe-joint fitting similar to that in the wing. To give an idea of scale, a man can work inside either torsion cell.

Embryonic as is the fixed horizontal surface, it is a complicated assembly for it contains the Hobson power units and the fixed part of the hinges and the actuating mechanisms. It has a structure with two spar webs, central and end ribs, a few chordwise

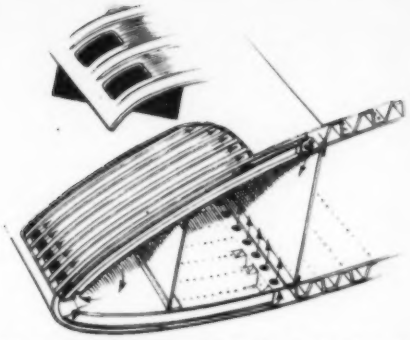


Left, the air-conditioning system

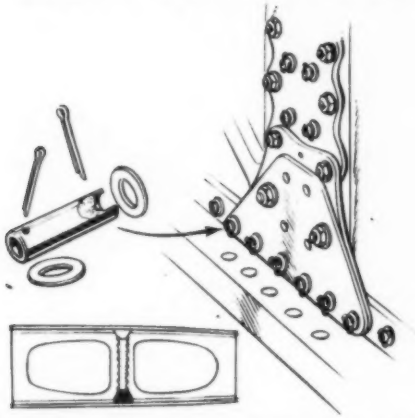
1 Bleed air (port)
2 Bleed air (stbd.)
3 Cooler
4 Port intake
5 Stbd. intake
6 Cold-air unit
7 C.a.u. inlet valve
8 C.a.u. by-pass valve
9 Flood-flow valve
10 Temp.-control valves
11 Press.-ratio valves
12 Cabin isolation cocks
13 Cross-feed cock
14 Ram-air valve
15 Water separator
16 Frequency changer
17 T/R units
18 Duct relief valve
19 Ground cooling
20 Pilot services
21 Bombing windows
22 Crew stations
23 Water press.-ratio valve
24 To wing injector pumps
25 To tank injectors and bomb bay
26 Radar cooling
27 Combined valve unit



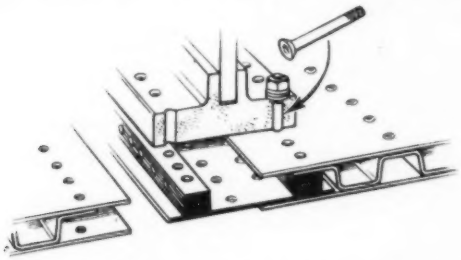
Typical of the Victor airframe is the stress-bearing door to the aileron power unit in the underside of the outer wing. Each side is secured by 33 patent fasteners



This sketch clarifies the construction of the wing leading edge, through which hot air is circulated for de-icing purposes. The air passes first into the feed channel at the front and thence flows back across the milled channel sheets into the scavenge duct ahead of the spar



Stress concentrations at the spar joints in way of the engine ducts are avoided by employing solid pins through a gusset plate with its rear face edges relieved to reduce compression. Below is one of the spar-boom sandwich panel joints, using an internal gusset (black)



contour members, a full sandwich top surface (spanwise corrugations), and a similar undersurface with a large access panel on each side with spanwise corrugations. The leading-edge is de-iced by hot air and has chordwise corrugations without an inner skin. Both the proboscis and tail fairings are of conventional construction.

Simplest of the control surfaces is the rudder. It has three hinges, a main front spar and a subsidiary rear spar to stabilize the skin and form a torsion box. The skin is again a Scandinavian sandwich, with the corrugations chordwise because there are virtually no longitudinal loads whereas aerial stiffness in the airstream is paramount.

In the case of the elevator, hinged about the inner third of its span, many of the problems of the wing are repeated. It has a main spar web in the plane of the hinges, with a lighter rear spar and an even lighter front one. The whole surface is double-skin sandwich covered, with spanwise corrugations between the main and rear spars, chordwise elsewhere, and the usual de-icing ducts are incorporated in the leading edge. The tip, outboard of the mass-balance horn, has four conventional ribs and ordinary skin. Like all the aerofoils on the Victor, the elevator has an exquisitely finished knife-edge at the rear.

Fuselage. Apart from one or two panels and the spar-bridge unit, the fuselage is devoid of sandwich structure. The reason for this is that the curvature of the skin and the load concentrations mean that normal aircraft practice is satisfactory.

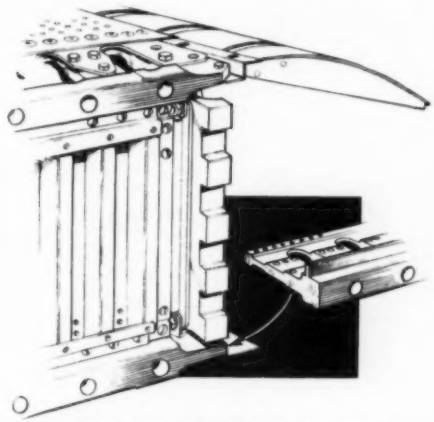
Athwartships, just ahead of the vast bomb bay and abaft the cabin, is the massive bridge which joins the three spar webs and torsion skin of the inner planes. In the Mk 2 this bridge unit stands eighteen inches proud of each side of the fuselage. The centre web is a heavy-gauge sandwich, with transverse corrugations, as also are the upper and lower surfaces of the box, while the front and rear webs are solid bulkheads with, in the case of the latter, massive forged booms.

The rear fuselage is built on to the bridge with its upper and lower longerons registering with the upper and lower surfaces of the box. With more than half the bottom of the fuselage consisting of the huge open belly of the bomb bay, it has to be, in effect, half a tube. The roof of the bomb bay has four longitudinal girders, and a stress-bearing floor to support the load, and the skin of the whole is held by C-section built-up frames. Top-hat skin stiffeners are used, spot-welded to the skin at the crowns. There is also a partial inner skin so that, by varying the spacing of the stiffeners, the structure can be adjusted to the local loading and the stress-distribution kept even. Double fastening of the brims to the frames is an aid to rigidity. Even so, there has to be considerable thickening of the skin gauge in areas of sound-wave battering from the jets, and in the Mk 2 the extra thrust of the Conways has required some doubler plates.

Both bomb doors are hydraulically retracted up in to the fuselage. Aft of the bomb bay there is a cylindrical section, with a larger under cutout for a dielectric panel, with inset sandwich diaphragms (or longitudinal bulkheads) which support the fin.

Finally comes the tailcone with its large air brakes. These have a linkage which initially opens them almost in parallel with the airflow, before they swing out. The Victor's air brakes have no limiting speed. In the extreme tail is a conical fairing obviously shrouding rearward-looking radar.

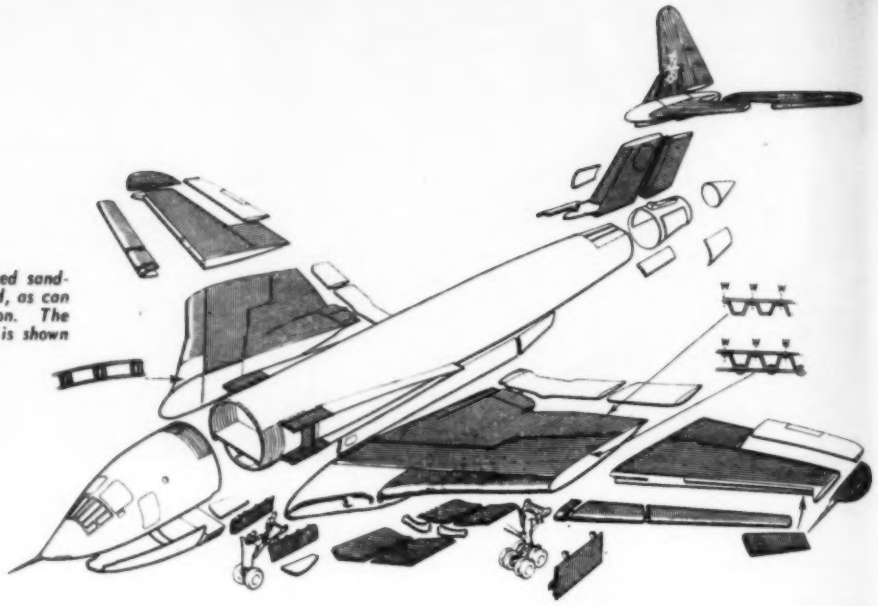
With its many cutouts, the cabin is a complex form for a pressurized compartment. Only the volume above the floor is pressurized and it is bounded by a rear semi-dome bulkhead and a tiny one in the nose formed by the bomb-aimer's window. An ingenious feature is the incorporation of the braces for the rear bulkhead into the navigator's table. The pressure floor has deep I-girders and crossbeams, while the cabin wall is quite conventional. To lessen fatigue problems the cabin is constructed of aluminium-copper alloys. Beneath the floor is a large glasscloth radome and, aft of it, a plenum chamber for equipment, which is mildly pressurized by ram air from the N.A.C.A. flush intakes in the nose. The latter are partially blanked in the Mk 2 since the absence of rectifiers means that less cooling air is needed.



At the joint between the inner and outer wings is a row of "pipe joints," with a dog-tooth spar end. Multiple bolts secure the rib members, which, as the arrow indicates, are slid into position late in the assembly sequence. The nose-flap shroud may also be seen

Undercarriage. The Electro-Hydraulic bogie undercarriage unit is so well-known that its description would be superfluous. Handley Page engineers praise it highly and say it not only came out lighter than was expected (3 per cent of the gross weight) but has given excellent reliability in service. The twin nosewheel unit gives 175 deg castoring angle, with hydraulic steering through a total angle of 90 deg.

Engine Installation. The Rolls-Royce Conways of the Mk 2 are supported on trunnion mountings from the relatively light webs aft of the spar. They are lifted into position by bomb hoists fitted to the top of the wing. The whole belly of each engine is laid bare by underwing panels—which, owing to the spar design, can be opened without using special jacking or trestling. The air is led into the engines by ducts of sandwich construction. Joining the ducts in the spars to each engine intake is an individual



In this diagram the corrugated sandwich panels may be discerned, as can the direction of corrugation. The location of welds and rivets is shown in an inset

cylindrical (sandwich) trunk, ingeniously attached and sealed by a species of overgrown Jubilee clip.

In the starboard stub wing (B.2 only) is mounted the Blackburn-Turboméca Artouste auxiliary power unit, which is used for l-p. air starting. The unit is fed by a retractable air scoop.

Powered Controls. The Victor control are fully duplicated and are without manual reversion. In addition to having duplicated Hobson actuating units, half the elevator, or one aileron, will always remain operative. When postulating the principles of the system, it was assumed that screw-jacks would not seize, that hydraulic motors would not jam and that the mechanical control linkage would remain operative; everything else was duplicated.

Each surface is actuated by a compact electro-fluid-mechanical unit through skew levers. The skew lever is a universal coupling mounted at 45 deg to the control-surface hinge line, which converts the linear action of the actuating jack into angular motion of the control surface. Each of the Hobson units consists of two continuously operating independent circuits, comprising a B.T.N. fan-cooled electric motor (A.C. on the Mk 2) driving an Integral hydraulic pump, a control valve, a hydraulic motor driving the output screw-jack through gearing, and a fluid reservoir. The whole is laid out flat so as to lie within the aerofoil, and it is of interest to note that each circuit has its independent cool-air supply ducted to it. The airflow to each reservoir is ingeniously regulated by a shutter actuated by a paraffin-wax piston; melting of the wax causes it to expand, extend the piston and close the shutter.

Pilot control movements are transmitted mechanically through a low-friction system specially engineered not to mask the artificial feel. Push-pull tubes are used, with ball-bearing guides and links to minimize backlash, while counterbalances are fitted to overcome inertia. The system is joined to each control unit by a simple linkage that relates the control-valve position with that of the screw-jack. The control column is connected to an artificial-feel unit which gives forces proportional to $(E.A.S.)^2$, modified by a spring.

On the Victor Mk 1 a yaw damper was fitted, but owing to the greater operating altitude of the Mk 2 a yaw/roll damper has been introduced to meet the increased stability problems. Both marks are fitted with a Mach trimmer, which automatically compensates for the nose-down trim change; the latter is not, however, a pitch damper.

Hydraulics. Designed by Electro-Hydraulics, the system comprises eight circuits: alighting gear, flaps, nose flaps, air brakes, bomb doors, wheel brakes, nosewheel steering and (Mk 2 only) ram-air turbine scoops—the Artouste a.p.u. intake is retracted electrically. A diagram shows the general principles of the system. There are normal supply and partially-duplicated emergency lines to each circuit, and the normal lines can be hand-pump fed for servicing.

Air Conditioning. Air conditioning of varying degrees has to be provided for crew and equipment. The nostrils on the cabin nose are the source of cooling air for the cabin and ram air for the equipment plenum chamber under the floor. Hot, high-pressure air is tapped from the compressors of all four engines for both the cabin and the thermal de-icing system. The ram air for the plenum chamber is fed directly through a fan. The remaining ram air is passed through cooler and cold-air units in the air-conditioning system, of which the whole supply comes from the compressors through pressure-ratio, temperature-control and flow-augmenter valves.

De-icing. Hot air is tapped from all four engine compressors and is delivered through non-return valves to port and starboard manifolds containing cocks which permit either half to feed wing and tail unit. Since the engine air is hotter than is necessary, it is augmented by ram air inducted by venturi jet pumps, thus reducing the drain on engine thrust. The mass-flow required has been carefully calculated, and the precise quantity is metred through flow-control valves. As the nose flaps extend, bellows valves bring ducts in the front-spar shrouds into circuit, closing again when the flaps are raised. The engine hot-air system de-ices the wing, tail and fin leading edges, the bomb bay and the cabin nose probe carrying the pitot head. Louvered vents on top of the wing and in the tips of the tail discharge to atmosphere.

Although the engine intake ducts are partially heated by passing hot air through the sandwich, the lips of the flow dividers have been treated with small areas of Napier Spraymat cyclic electric heaters. The wing-tip extensions of the Mk 2 are similarly protected.

Fuel System. This remains classified in quantity and in detail. It can be said, however, that fuel is carried in both wings and fuselage, while huge under-wing tanks have been seen on the Mk 1. The handling of the great weight of fuel, consumed at a high rate, has been removed from the burdens of the crew by auto fuel-proportioning, which ensures that the c.g. remains within its limits as the tanks empty. Pressure-fuelling equipment is in the port wing root. It is understood that Flight Refuelling has been catered for in the design of the system.

Electrics (Mk 2). The main aircraft supply by English Electric comes from four alternators driven from the engines by constant-speed units. This supply is 200V, 3-phase at a constant-frequency of 400 c/s. From the main source a 28V D.C. supply is obtained through transformer/rectifiers used to control the high-voltage circuits, for cock operation and similar relay devices. Transformers are used to obtain a 115v, 3-phase, 400 c/s supply for some radio services and for the magnetic amplifiers that are widely used in the systems. Finally, there is a 115V, single-phase 1,600 c/s supply for radio and radar equipment, which is obtained via frequency changers.

Emergency, and when necessary ground supplies, are provided by the Blackburn-Turboméca Artouste a.p.m., which drives a 200V, 3-phase, 400 c/s alternator feeding into the main aircraft busbars. As a standby for the flying controls only (in practice to bridge the gap while the a.p.u. is being started) there are two retractable Rotax ram-air turbo-alternators in the top of the rear fuselage. These provide a 200V, 3-phase, 360 c/s supply, and they deliver independently to each half of the duplicated power control system. Two 28V batteries are carried as standby for the D.C. services.

J. H. S.

References

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Correspondence

The Battle of Britain Veterans

(From Sir Sydney Camm, C.B.E., F.R.Ae.S.)

I WAS interested to read the two letters under this heading in your October 9 issue and I thought you would like to know that we, i.e., Hawker Aircraft, still maintain our last Hurricane in flying condition. It is demonstrated from time to time by our chief test pilot, Mr. Bill Bedford. We also have in flying condition a Hart biplane with Rolls-Royce Kestrel engine, the date of construction of this being about 1930. As you know, this machine was often used by Mr. John Yoxall for photographic purposes.

One difficulty in keeping these old machines flying is not so much a question of aircraft structure as a question of engine spares.

Kingston-upon-Thames, Surrey. S. CAMM,
Director and Chief Engineer, Hawker Aircraft Ltd.

Convertiplane ?

ON a recent visit to a cinema I was rather intrigued by a film, currently in circulation, entitled *Jet Storm*. It was based on personal reactions of the passengers on finding that there was a bomb on the plane, and as such was excellently done.

However, the aircraft observed warming up was one of Aeroflot's Tu-104s. The passengers then boarded what was unmistakably a Viscount; on take-off they switched back to the Tu-104; in the air a model resembling a Tu-104 (with pronounced dihedral) was used; and on landing the aircraft was undoubtedly a DC-7!

With such a star-studded cast, was there nothing left for a technical adviser?

London Airport, Middx. R. S. E. MOGER.

"Jet-age Growing Pains"

IN his article "Jet-age Growing Pains" (*Flight*, October 9), M. J. Hardy says that the new airliners are costing U.S. airlines almost double the figures originally cited in the brochures and he states further that the present high load-factors being experienced by jets may be needed to make their operations profitable.

The only Boeing brochure we could find here in Geneva was dated February 1957, but there is no reason to believe that its figures are less rosy than any others Boeing gave out in the jet sales campaign.

This brochure [copy enclosed] shows that at a range of 2,000 statute miles the direct costs for the Boeing 707-120 were estimated to be $1.70 per mile. The C.A.B. records for the second quarter of 1959 show that American Airlines' per-mile cost was $1.94. This is a great deal less than twice the brochure figure, although admittedly it is higher than we had estimated almost three years ago. It is not intended here to analyse the reasons for the higher costs, but it is reasonable to say that direct operating costs of new airplanes are always higher than anticipated for some time after introduction and then become appreciably lower after the airplanes have been in service for a year or so. Increased daily utilization is probably the most important reason why costs go down over a period of time, but personnel also become more efficient in maintenance operations, effectively reducing costs.

Using the direct operating costs as reported by C.A.B., and assuming that the indirect operating costs are 100 per cent of the direct costs (a reasonable assumption, based on past experience), a transcontinental flight in the Model 707-120 costs the operator about $9,500. American Airlines have been using a mixed-interior first-class coach, varying the proportions from time to time as required by the demand. The interior they have chosen gives a total revenue of about $15,000 if every seat is filled, regardless of the proportion of first class to coach seats. In calculating this revenue, I have not included the $10 per passenger jet surcharge now being paid by passengers for a 707 transcontinental flight. This surcharge increases the possible revenue about $1,000 per flight.

Discounting the jet surcharge revenue, the break-even load factor on a transcontinental flight even with the high initial operating costs is 63.3 per cent. American Airlines have been carrying more than 6,000 lb of cargo and mail on each flight, and the revenue from this reduces the break-even number of passengers required.

For Pan American, the direct cost for the same period, as given in the latest C.A.B. reports, is $2.39 per mile. Pan American have been operating their Boeing 707-120 airplanes with 72 economy and 40 de luxe seats. The economy fare is $257 one way, plus $15 jet surcharge, and the de luxe passengers pay a first-class fare of $440, plus $20 jet surcharge, plus an additional $60 de luxe surcharge.

The September 1958 "Flight" photograph of an Avro Vulcan B.1 referred to in the letter below from Mr. B. M. Service

At the costs shown in the C.A.B. report the total cost of a London - New York flight by the 707-120 (assuming 100 per cent indirect costs) is approximately $16,400. The maximum passenger revenue possible, neglecting the jet surcharges of $15 (economy) and $20 (de luxe), is $18,504 from the economy passengers and $20,000 from the de luxe passengers. This makes the break-even load factor 42.7 per cent. Even when carrying only ten de luxe passengers, the airplane would break even with 43 economy passengers, which is roughly 60 per cent of the 72 economy seats carried.

As is shown here, the economic picture of the initial jet operation is not as good as Boeing's original estimates, but it is still good enough to make the jets money-makers at reasonable load-factors. With lowered costs as time goes by, the case for lowering fares (yes, even with jets), looks very promising.

Geneva. ROBERT C. BRUMAGE,
European Engineering Representative, Boeing Airplane Co.

I READ with great interest Mr. M. J. Hardy's informative article appearing in your issue of October 9, which, as he claims, does put the operation of modern jet aircraft in true perspective.

However, I was disturbed to learn that your contributor still believes that the incident on February 3, 1959, when a Pan American 707 dived steeply from 35,000ft to 6,000ft, was due to autopilot failure. The investigation by C.A.A. disclosed that the autopilot was at all times serviceable and behaved exactly as it should have behaved. To refresh Mr. Hardy's memory, the captain was subsequently fined $1,000 whilst the first officer was suspended from flying for six months.

On behalf of the Bendix Aviation Corporation, the Boeing Aircraft Corporation and Elliott Brothers (London) Ltd., as well as this company, I will be grateful if you will thus allow me to correct any misconception of the truth of the 707 incident conveyed to your readers by Mr. Hardy's otherwise excellent article.

London, W.1. E. G. MONK,
Managing Director, Bendix Ltd.

Non-smoking Olympus

I WAS most interested to read Roger Bacon's note (October 2) concerning the smoke eliminator fitted to one of the Vulcan B.2's engines at Farnborough this year. I believe, however, that research on this device has been going on for longer than you realized and photographic evidence would seem to bear me out. If you examine the photograph published on page 448 of the September 12, 1958, issue of *Flight* you will notice that the No. 4 engine of the Vulcan B.1 was also using the smoke eliminator; or, I wonder, could there have been a shortage of Olympus engines?

Feltham, Mddx. B. M. SERVICE.

IN BRIEF

A reader engaged on historical research would like to know the name of the air correspondent of *The Observer* Sunday newspaper *circa* 1916 (*The Observer* is apparently unable to assist). His weekly articles were usually unsigned, but on two occasions he used the initials "C.W." Any information addressed to the Editor of *Flight* will be forwarded to our correspondent.

RETROSPECT

From "Flight" of October 30, 1909

The First Lady Flier: Yet another sphere which some had thought man would, for some time, at any rate, retain for his own has been invaded by the gentler sex. Baroness La Roche has been successfully piloting a Voisin biplane, and has thereby earned the right to be known as the first lady flier or "aviatress." For some time the Baroness has been taking lessons from M. Chateau, the Voisin instructor, at Chalons, and on Friday of last week she was able to take the wheel for the first time. This initial voyage into the air was only a very short one, and *terra firma* was regained after 300 yards; but on the following day the parade ground at Chalons was encircled twice, the turnings being made with consummate ease. During this flight of about four miles there was a strong gusty wind blowing, but after the first two turnings the Baroness said that it did not bother her, as she had the machine completely under control.

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns. Names and addresses of writers, not for publication in detail, must in all cases accompany letters.

Near Kansas City, Mid-Continent International is the overhaul base at which T.W.A. undertakes base overhauls and maintenance administration

IN the United States—whence the author of this article has recently returned—the phrase "Take the jet" has real significance; the Boeing 707, and the Douglas DC-8 and Convair 880 and 600 which are to follow it, are altering the established pattern of air transport at a rate that gives some justification for the belief that a new transport era has dawned. Certainly the actions and organizations of U.S. carriers are being swept by the keen wind of a new enthusiasm. Some of the changes that are taking place and the thinking that has engendered them are recounted in this description of the activities of Trans World Airlines at their training and engineering headquarters in Missouri.

MID-CONTINENT INTERNATIONAL

How T.W.A. Maintains its Jets

BY ALASTAIR PUGH

AT 8.43 a.m. exactly our Chevrolet came gliding to a halt outside the imposing entrance to T.W.A.'s Mid-Continent headquarters, 17 miles north of Kansas City. We stepped from the 90 degrees of an August morning into the air-conditioned coolness of the spacious, welcoming vestibule, were elevated to the second floor and—like Alice's White Rabbit—hurried along a corridor lined with doors stretching distantly before us. At 8.44½ we turned through a door leading into a shaded conference room overlooked by a screen and lectern and walled with charts and blackboards. A dozen or so engineers were seated at a big table; others had taken their places on chairs around the walls. Precisely half a minute later, at a quarter to nine exactly, an engineer rose, crossed to the lectern and began reading the first of the day's reports on T.W.A.'s operations.

In the past 24 hours, he said, there had been no major weather delays on domestic flights but because of low stratus one international flight had been operated through Dublin instead of Shannon. Delays at the flight origin point on this particular day had been 17, owing to technical faults, and the percentage of exactly on-time departures recorded was 92.5 per cent; all the 286,639 scheduled domestic miles had been flown without default.

As he spoke, the operational briefing resumé which he was studying was projected on to the screen behind him: a presentation of T.W.A.'s current record of regularity. Each delay was briefly analysed, and here came the first indication of the special emphasis placed on jet operations; partly because it is a new type to be introduced, partly because it is so different, analysis of 707 operations is separated from that of the other aircraft in the fleet.

Since the previous day's meeting, the technical compère continued, there had been two unscheduled piston-engine changes and three cylinder-changes, and a 707 on a flight from Idlewild had damaged a wing-tip while taxying.

Here the rapid flow of report was interrupted. Ray Dunn, vice-president of technical services and the man answerable for the smooth running of T.W.A.'s fleet, wanted to know from the responsible area engineer what corrective and disciplinary action had been taken as a result of the wing-tip incident. Had the men responsible been involved in a taxying accident before? No, came the reply, they had not; they had not been careless, but they had made an error of judgment. The probing continued. What lessons were there to be learned? Was it possible, the vice-president asked, that swept wings were causing difficulties of judgment? What action could be taken?

I was sitting in on the daily session that starts each day's work at M.C.I., where over the entire domestic network every technical incident and every rectification that has occurred since the previous meeting is reported upon and examined. The atmosphere of the briefing room was, I thought, surprisingly tense and conversation compellingly terse for a meeting that took place every day; the inference was that this daily conference is treated very seriously indeed.

Each engineer with a report to make took his turn at the lectern and for each Ray Dunn had probing, quick-fire questions. One incident concerned the leading-edge flaps of the Boeing 707; T.W.A. had experienced no trouble but one operator had discovered some cracks and another airline had lost a flap completely. "*This day*," said Mr. Dunn, "let's see that a set inspection procedure is established. How good have we been?" he asked. "After we heard of the trouble, how quickly did we move? What is our fore-flap supply position?"

The answer was that action had been taken very quickly indeed, and on the basis of other operators' experience an inspection instruction had been sent out on the same day, before any F.A.A. requirement or instructions from anyone else had been received. Because this might be a sonic fatigue problem, Boeing had also been contacted for advice.

Next, engineers with particular mechanical snags and worries presented them to the attentive audience of 30-odd engineers that filled the room. Wherever possible, the piece of hardware with which the discussion was concerned was held up for inspection, and where it was not (one such case was an oil-sludge difficulty with 749A propellers) a series of photographs was projected on the screen. A statement of difficulties alone was clearly not enough; the impression I gained was that this team was really crowding all its problems, and crowding Boeing and Lockheed and every other manufacturer and supplier of components to keep on top of all their difficulties.

Listening to the explanations and suggestions of the various engineers, I was struck by the articulate manner in which each case-history was presented. I wondered if this ability was perhaps an unexpected national characteristic or if special training had perhaps been given. Later, over an excellent help-yourself lunch in the canteen used by highest and lowest alike, I was told by Ray Dunn that this ability was really a result of these particular briefing sessions, where brevity was strongly encouraged and where complex subjects had to be made comprehensible to specialists in other fields. Every department is represented—maintenance, flight test, inspection, purchasing, overhaul planning and so on, and the daily briefing session on the five working days of the week is each department's opportunity for keeping thoroughly up to date with what is going on, not only within the overhaul organization but down the routes as well.

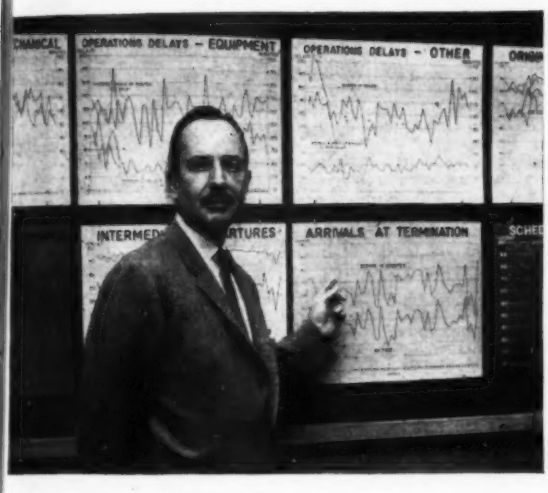
This daily discussion—which relies on detailed and up-to-the-minute reports from 12 major stations on the airline's domestic network—would be impossible were it not for technical innovations that T.W.A. have introduced to bring overhaul-base efficiency to stations down the routes.

Perhaps the most novel of these is the P.L.F. system—the private line 'phone. This is an extensive Bell telephone network which can instantly connect the Kansas City base with the field technical foreman at any and every one of T.W.A.'s major

domestic terminals. Not only does this allow a very complete system of snag reporting to be built up but, reciprocally, enables the skilled engineering talent that is concentrated at Kansas City to make almost on-the-spot recommendations and decisions. The advice that is passed to one station is immediately available for everyone else; if a snag has once occurred, every maintenance foreman on the line will know how to recognize it if ever he has to deal with it himself—one of the first tenets of preventative maintenance.

Because engineering skill can safely be centralized in this way it is also possible to adjust the amount of training that must be given to maintenance engineers. The technical foremen are of course very skilled men, but—"you have to be a pretty solid boy to solve every problem that can arise on an airplane as complex as the 707."

It is this greater technical complexity of the jets which has given rise to the airline's new philosophy of maintenance. While it was feasible with a 749 or Super-G Constellation for one man to become a specialist in the complete aircraft, with the 707 this is no longer considered worth the immense training effort that would be involved. Instead, a new system was established (development started when the 1649A went into service) whereby technical-speciality foremen (in powerplants, systems, structure, electronics and electrics) are stationed at the major maintenance bases. Administratively, these men come under local maintenance supervision, but technically they are responsible to the engineering division, whence they obtain technical guidance and control. Each of these specialists is given "all the training that is available for his assigned speciality" both from within T.W.A. and from airframe and component manufacturers.



On the speciality foremen depends correction at local level of faults on the systems for which they are responsible, and by the P.L.F. method they can enlist the aid of the airline's engineering division specialists on powerplants, hydraulics, electrics or instruments at any hour of day or night since—disturbing thought—the P.L.F. is also connected to each engineer's home.

Once a day, and more often if necessary, a cross-Continent maintenance briefing is held over the P.L.F. A maintenance co-ordinator seated at a horseshoe-shaped console in the M.C.I. building at Kansas City dials off and checks the attendance of about 12 stations in 12 seconds, and then the current crop of problems can be discussed over open broadcast. The co-ordinator's console is manned around the clock, and it is the responsibility of the man on duty to call up specialist engineers as they are required. He also records statistical information from the outlying station, including a routine check of actual against scheduled departure times.

In this way the co-ordinator has an extremely up-to-date knowledge of the airline's current performance, its snags and delays and the problems that are being encountered. If the same difficulty occurs on three occasions over a short space of time it is not to be supposed that this is merely coincidence, and special action is taken to draw attention to the particular "squawk," which can subsequently be closely watched.

Two catch-phrases frequently heard at M.C.I. indicate something of the philosophy of the airline's engineering centre. One is: "Every time a pilot takes off a $5 million business goes with him," and the other: "Attention to detail is everything." These phrases may well be the keystones to the philosophy that brought the overhaul base into being rather less than two years ago.

Opening the daily maintenance briefing session at M.C.I.; Ray Dunn, v.-p. technical services, is seated at the head of the table

Punctuality affects operations and maintenance alike. Here, in front of T.W.A.'s delay history, is Floyd Hall, vice-president transportation

The Mid-West has always been T.W.A.'s *alma mater* (it is also, they say, the place where steaks were born) and it was natural that a Missouri site not far from Kansas City should be chosen for a base large enough to undertake the overhaul not only of the airline's piston-engined fleet but the 707s and Convair 880s that are now coming, or about to come, into service.

The need was for an airfield and an overhaul centre of sufficient size to undertake every major overhaul of airframes and powerplants for many years ahead. Characteristically, design began with a clean sheet of paper, and the buildings that are the outcome were planned by T.W.A. themselves as being the most suitable for their needs.

The layout is intriguing. Cantilevered from a central spine housing the administration headquarters are the roofs of two extensive airframe overhaul bays, which thus have unrestricted access from any of three sides. The building is 1,000ft long and it was the corridor running throughout the length of the spine that I had seen on my first acquaintance with M.C.I. A feature of this building is that it could be extended with little disturbance to the existing installation.

In a functional way, much of the interior is quite beautiful; the hot summer sunshine of Missouri is tempered by shaded windows (or often no windows at all) and by the air conditioning without which living would soon become intolerable; offices and corridors are finished in a cool green. An example of the Dunn dictum of "attention to detail" was to be seen on the stairs leading down into the basement. Here, against dark green-painted brick walls, each corner was picked out with a little triangle of white—a sure indicator of overlooked dust. Need I add that they were remarkably clean?

Two years ago, when colleague Michael Ramsden visited Lockheed and Douglas on the West Coast, he reported being able to buy a cup of coffee (with optional milk and sugar) from a slot machine, as you can now do in England. Alas, I have to report that still we seem to lag behind. At M.C.I. I noticed your nickel will now buy a slice of fresh pie or a bun as well.

Both the airframe and adjacent overhaul buildings are equipped with overhead basket conveyors and—just like a big haberdashery shop—with that wonderful pneumatic-tube communication system that has yet to be bettered as a method of conducting an internal post; at M.C.I. it is used both for the despatch of paperwork and for transmission of small components. As a dust-preventative measure the engine overhaul building is windowless and completely air conditioned by steam produced by the dynamometers in the engine test cells.

The cells—again a T.W.A. design—are worked hard. By using a hydraulic dynamometer coupled directly to the crankshaft nose—no propeller is fitted—a great deal of time is saved and the cells are made correspondingly smaller. At the moment, all the work is confined to the half-a-dozen different piston engines in use in the fleet; the Boeing 707-131's JT3s are at present returned to Pratt & Whitney for overhaul, but by April next year will be passing through the overhaul base alongside the piston engines.

So highly attuned to piston-engined overhaul is the present arrangement that I asked whether any dislocation will occur when gas turbine overhaul is introduced as well. The philosophy here is that an integrated operation is so well worthwhile in terms of rapidity and low-cost that it makes good sense to establish a new

Taken from the inside of the building shown on page 474, this photo-graph demonstrates the extent of the sliding doors that is possible with a suspended roof. They solve a major parking problem

MID-CONTINENT INTERNATIONAL . . .

overhaul line. By deferring the start of jet engine overhaul, T.W.A. expect to integrate the new lines within its present facility; planning for this has already started and by the end of 1960 throughput should be five engines a day.

There is as yet little evidence of 707s under overhaul at Kansas City, as insufficient hours have so far been accumulated for base overhauls to be needed. The preventative maintenance programme is very similar to that conducted on the piston-engined fleet: there is a daily pre-flight check, 50-hour check A, 100-hour check B, and detailed inspection at every 200-hour check C. The multiple of the check Cs which occurs at 800 hours is considerably greater in scope, and involves more man-hours than any other check except base overhaul, which at the moment is set at 2,500 hours.

T.W.A. reckon that, on balance, maintenance of the Boeing 707s will be comparable in man-hour and elapsed-time requirements with their piston-engined fleets. Much more specialized knowledge and ground test equipment is required, but reliability and "maintainability" should be better when the aircraft have fully shaken down.

The number of technical delays that occur is still some way above T.W.A.'s objective, but reliability has otherwise been quite good. T.W.A. have not suffered greatly from the endemic 707 troubles experienced by other airlines (they are prepared to say that this is no coincidence) but air conditioning has been the subject of a good deal of co-operative development with Boeing. Water injection has been an intransigent problem that has only quite recently been brought to book; the difficulty is that an enormous (up to 700 gal) amount of water is pumped into the engines during the first 60 sec or so of a flight, and the injection system has not always been capable of sustaining repeated operations. The problem of putting that amount of water through small pumps is quite considerable, and failures have apparently occurred more from mechanical breakdown of bearings, and so on, than from any inherent fault of system design.

Between March 15, when jet services started, and the end of August, Boeing 707 utilization hours rose from an average of 7.5 hr per day to 9.5 hr and 49,253 engine hours were flown. During this time there were six unscheduled engine removals, an average of 0.00012 per 1,000 engine hours. By comparison, the record of nine Constellation 1049As was 47,932 engine hours with 27 unscheduled engine changes—an average of 0.0057 per 1,000 engine hours.

Provisioning of spare parts along the routes for an aircraft of 707 size is a problem to daunt the most experienced spares provisioning department; operational profit can only too easily be absorbed by over- or under-provisioning, or by holding insufficient or surplus parts at any particular base. The measure of the problem is that some 20,000 or more parts must be stocked (and replaced) at 50-100 stations in the route pattern, and the more critical the schedules and expensive the aircraft the more rapid and efficient the allocation of spare parts must be.

A few years ago the only guide on which an airline could rely was experience, particularly in the first detailed and comprehensive engineering assessment of what spares must be ordered. But—used with discretion—multi-channel queueing theory and the electronic computer are useful new tools in balancing the inventory of spares holdings against a reasonable capital investment.

This point was emphasized for me by Jim Shaunty, T.W.A.'s enthusiastic director of stores. "Computer techniques and the results they provide," he said, "give us the only convincing arguments we have ever had for demonstrating to our management the results—in terms of probable shortages and delays—of the investment of so many dollars in spare parts. In fact this gives us a competitive advantage over other airlines, because we now expect to be able to estimate our spares flow as soon as our detailed investigation into the parts that we shall require is completed."

On more than one occasion during our discussions Mr. Shaunty paid tribute to the contribution of Mr. Jack Taylor, of B.O.A.C.'s operations research branch, in the development of analytical techniques that are now being adopted. Briefly, computation starts from a basic premise, e.g., that from a given list of parts the total number of shortages per year will be equal to or less than a given specification, regardless of their cost.

The other "knowns" that must then be considered are the time taken to restock a part at any base, the cost of each part, and the usage rate of each part at each station. In order to determine usage rates, some assumptions must be made, and the best prediction is probably related to the number of landings rather than on the number of hours flown, but here the results of operating experience are obviously going to be required. The computer is used to determine the number of spares to allocate, against the supply time in weeks, for shortages expected to occur once in half a year, once a year, once in two years, and so on.

In answer to a question about spares pooling with other airlines I was told that now that T.W.A. had for the first time similar equipment to other U.S. airlines, it was exploiting pooling to the fullest extent, and hoped to conclude pooling programmes on both Boeings and Convairs—a world-wide agreement for the Boeing -331 spares between T.W.A. and other U.S. and international airlines (including B.O.A.C.) is virtually complete.

To sum up at this point, the spearheads of T.W.A.'s engineering attack on the problems of introducing the first of the big jets into service have been:—

- Holding daily briefing sessions—embracing all departments—to keep abreast and ahead of engineering problems.
- Setting up a system of communications which makes central control of domestic operations possible.
- Instituting a completely up-to-date record of all delays, snags and checks.
- Making an appreciation of the investment which each jet represents and which, when airborne, is effectively in the charge of one man.
- Training specialist technical foremen for service at every major maintenance base.
- Using computer techniques to determine spares holdings and the probable results of a specified investment.
- Resolving new equipment problems by computer analysis.
- Vigorous spares pooling.
- Attention to detail.
- Attention to detail.
- Attention to detail.

(*Continued on page 481*)

Overnite wash-n'-dri: T.W.A.'s pride of appearance in the fleet starts with modern wash-down equipment at the overhaul base

The first appearance of a Britannia in the colours of the Argentine independent Transcontinental S.A. was made on October 20, when the aircraft took off from Short's airfield at Sydenham. It is a Britannia 308, one of the five ex-Northeast 305s

AIR COMMERCE

TOWARDS AN "AIR ARAB"

IN reviewing the recent settlement between B.O.A.C. and M.E.A., *Flight* referred to the significance of a trend among Arab airline operators towards an alliance of the Air Union type. Already the words "Air Arab" have become a title around which Arab operators have rallied, and a recent meeting in Beirut seems to have been quite fruitful. Sponsored by the Arab League, and with Sheikh Najib Alamuddin of Middle East Airlines as its chairman and one of its most enthusiastic advocates, the meeting was attended by representatives of airline interests in Jordan, Saudi Arabia, Iraq, the U.A.R. and, of course, the Lebanon. This suggests that the airlines involved are Air Jordan, Saudi Arabian Airlines, Iraqi Airways, Misrair and M.E.A.

One proposal appears to have been the unification of the air legislation of each nation to simplify the achievement of joint operations. It seems probable, too, that the headquarters of Air Arab would be in Beirut—the major air transport cross-roads of the Middle East, and the capital of a relatively neutral Arab state.

Sheikh Alamuddin has said that M.E.A.'s possible association with Air Arab would not prejudice its association with B.O.A.C., or vice versa. *The Financial Times* reports that the routes proposed for operation are inter-Arab routes and long-haul routes to South America, the Far East and South Africa (routes which are not at present flown by Arab companies).

The decisions and recommendations of the recent Beirut conference are to be submitted to the Economic Council of the Arab League, which was recently given an independent status to enable Kuwait and other Persian Gulf states to join. It is thus possible that Kuwait Airways might be included in an "Air Arab."

A SECOND 707 TRAINING ACCIDENT

AS briefly reported last week, a Boeing 707-227 of Braniff Airways crashed on a training flight near Arlington, Washington, 40 miles north of Seattle, on October 20.

Following the shedding of three engines in flight, it is reported, a Boeing test pilot on board, Russell Baum, took over and managed to crash-land the aircraft on a sandbank in the Stillaguamish River. With three others on the flight deck he lost his life, but four other crew-members, who had gone into the tail, survived.

The Boeing company issued the following statement after the accident:—

"A report by the survivors indicated that three engines were torn from the aircraft at 12,000ft, as a result of a violent manœuvre due to a misapplication of controls during recovery from the demonstration of unusual flight attitudes. The pilot took over and recovered the aircraft into level flight. With power from the remaining engine he made a controlled wheels-up landing in the best available spot, resulting in the saving of four lives."

It is not yet known whether the "unusual flight attitudes" being demonstrated were with two engines out on one side, which was the condition when an American Airlines crew lost control on a 707 training flight over Long Island on August 15 and crashed with the loss of all five on board. After that accident the F.A.A. required "two-engine-out" flying to be carried out above 5,000ft.

As noted in a review of the insurance implications on page 480, the aircraft was legally owned by Boeing at the time of the accident. One of five Boeing 707s ordered by Braniff, it differs from all other variants in having the short-body domestic-sized fuselage with Intercontinental-type Pratt & Whitney JT4s.

NEW TECHNIQUES IN AIR TRANSPORT

BOTH I.A.T.A. and I.C.A.O. have recently allowed themselves a measure of self-congratulation on the accuracy of their forecasts of jet operational requirements—I.A.T.A. for the work of its 1950 Technical Conference and I.C.A.O. for the Jet Operations Requirements Panel which was set up in 1957. Although neither body is prepared to say that everything is now rosy in the jet operations garden, by and large the introductory year is acknowledged to have gone quite smoothly.

The biggest problem now is that of the upper altitudes in the airspace itself, where the airlines are demanding a more unselfish outlook on the part of military aviation. Something has already been done to integrate civil and military operations: Euro-control—the single A.T.C. agency established by several countries in Western Europe—has been cited by I.A.T.A. "as an example which other countries should be encouraged to follow." Within two to three years this system should provide full co-ordination on the dense and highly complex European network.

But much more must be done to improve world-wide navigation and communications facilities. A step in the right direction has already been taken on the North Atlantic, where V.H.F. forward-scatter has been replaced by the cable link between Newfoundland, Iceland, Greenland and the United Kingdom; and I.A.T.A. are now recommending for regional services on the North Atlantic that wireless telegraphy be terminated completely and the frequencies made available to radio-telephony.

Yet in other parts of the world point-to-point communications by commercial telegram take as long to complete their journeys as the turbine-powered aircraft they concern. Thus the airlines are coming to rely more and more on private telegraph circuits; use of these private facilities is increasing by about 25 per cent each year.

Both the I.A.T.A. Technical Conference (which reported at the recent a.g.m. in Tokyo) and I.C.A.O.'s Air Navigation Commission, which reported at Montreal this month, have again considered *en route* and terminal navigation aids, I.A.T.A. firmly endorsing V.O.R. on a building block basis supplemented by D.M.E.

I.C.A.O.'s Air Navigation Commission were less definite. They merely made the point that "there must be a highly accurate navigation system" and that for holding there may be a need for "a specially located radio-navigation aid since those provided for *en route* and terminal navigation may be unsatisfactory." Another I.C.A.O. recommendation was that in climb to cruising altitude and for precision in descent "there is a need for an aid which will enable jet aircraft to maintain a prescribed track with adequate precision and to have accurate knowledge of its distance along the track." The air traffic control system required an absolute minimum of deviation from filed flight-plans; if changes were necessary these should be confined to routes rather than to aircraft altitudes—stipulations which may suggest that the last word in short-range aids has yet to be said.

On the important subject of all-weather landing the I.A.T.A. Technical Conference reported that they had carried out a review of developments and that several special groups were to study automatic landing and take-off in all-weather conditions. This important goal, the Committee said, could be reached only in an evolutionary manner. Not only must existing instrument-landing techniques be improved, but additional aids should be provided to guide aircraft during approach, landing, take-off and taxying.

This last point was also the concern of I.C.A.O., who suggested that an aid might be required to expedite aerodrome traffic at large aerodromes; surveillance radar would be necessary for jets.

The Organization have now laid down some definite requirements for meteorological forecasts. Runway temperature—to an accuracy of ± 1 deg C—at the average height of turbine engine intakes should be forecast two hours before take-off; wind velocity during the climb to initial cruising altitude should be given; and temperature at pressure levels of up to 45,000ft should be forecast with an accuracy of ± 3 deg C.

This is Boeing's mock-up of the 735 swing tail cargo liner on trestles at Boeing's plant at Renton, Washington. Claimed payload is 100,000 lb with the aircraft available for delivery in 1961

AIR COMMERCE . . .

ITALY ASKS FOR MORE

RESENTMENT has been expressed in Italy at the refusal of the U.K. to allow Alitalia to increase transatlantic flights through London from four to seven per week during the coming year. The Italian point of view is that, as an agreement for seven flights a week in 1963 was signed last year, this request does no more than anticipate by three years an agreed and foreseen development.

But a compromise already appears to be on the way: at the recent meeting in Rome of the joint Anglo-Italian Standing Committee for Civil Aviation it is reported that agreement was reached on "an exchange of new and increased schedules" for Alitalia.

THE BATTLE FOR BLACKBUSHE

HELD at Blackbushe Airport on October 15 was the first meeting of a number of companies who have formed themselves into a Blackbushe Airport Tenants' Association. In parallel with a similar association formed to fight for the airport at Croydon, their aim is to keep the airport open. Those represented included Claydon Aviation (Pegasus Airlines); Orion Airways; Continental Air Transport; Blue Air; Falcon Airways; Danair; Heather Light Engineering; Morton/Shell Aircraft; Airwork Services; Staravia; Morton Engineering Services; Racal Instruments; Ingleby Oddy and the Blackbushe Car Collection Agency.

After electing a chairman it was decided to write to the newly appointed Minister of Aviation to request a discussion about the closure of Blackbushe and to remind him of his predecessor's promise to meet the operators in September (a promise he had been unable to keep due to the intervention of the general election). As first steps in their campaign the Tenants' Association have sent a copy of this letter to Sir Eric Errington, the local M.P., and made a close assessment of the reasons which the M.T.C.A. had given for closing down the airport in mid-1960 (see *Flight*, August 21, 1959, page 57). The Committee of the Tenants' Association agreed that the reasons given could, without exception, be "categorically refuted."

CAPITAL VISCOUNT ACCIDENT REPORT

THE C.A.B. report on the Capital Airlines Viscount which broke up over Maryland on May 16, with the loss of 31 lives, attributes the cause to "violent air turbulence." The report goes on to say that "the major disintegration sequence took less than one second."

The aircraft was *en route* from New York to Atlanta at about 14,000ft when it encountered severe turbulence in which the pilot lost control. Considerable speed was built up in the ensuing dive and the aircraft disintegrated at about 5,000ft as a result of excessive stress. Before making their report, the C.A.B. examined the structure of the Viscount but had no criticisms to make. There was no evidence of a lightning strike, fire, explosion or mechanical failure.

The report criticized the action of the Capital Airlines' despatcher and suggested that the accident might have been averted if he had passed on to the captain a late warning of thunderstorms and unusual turbulence in the area. Capital have protested against this finding and said that the pilot was warned specifically about bad weather before take-off; the despatcher did not pass on a late "flash" about the weather because he believed that it would be better to go on the original forecast. The Viscount was equipped with weather radar but it was not working on this flight. Storm-warning radar is not compulsory equipment, but this accident seems likely to prompt F.A.A. legislation making it so on all U.S. civil transport aircraft (see "You Must Have Radar," *Flight*, August 28, 1959, page 93).

B.E.A.'s WINTER TRAINING

B.E.A. have a busy winter ahead of them training pilots for their Comet, Vanguard and Viscount fleets. *Intercom*, B.E.A.'s flying-staff journal, says that the programme shows that about half the total number of pilots are undergoing conversion training of one sort or another; 90 flight-deck staff are required for Comets, 32 (initially) for Vanguards, 121 for Viscount 800s and 105 for Viscount 700s; and next summer training will begin on Heralds.

Steps taken to get this big programme through include using Stansted for Comet flight training, partly to cut down "dead" flying at London Airport and partly in order that all the staff may be together in the vicinity of the airfield, thus permitting quick changes of programme.

A Comet simulator—the first for B.E.A. with "rock-'n'-roll"—is in the process of assembly at Heston and should be working by the beginning of November. A simulator for the Vanguard is under construction and should be available for training at Heston in May or June.

Crews on the Viscount 802/806 courses will also use what B.E.A. call "the poor man's simulator," an airline-designed systems trainer intended for consolidation of lecture-room training.

Vanguard training is now to start on November 9; nine development pilots are to begin training then for the route development programme which is to start at the beginning of January. Another 23 pilots will be trained for the London - Paris services from July onwards, and ground courses for them will begin in April and May next year. Finally, says *Intercom*, all full courses will be given air traffic control lectures. Comet courses will receive special treatment to familiarize them with the special problems of A.T.C. for high-speed and high-altitude aircraft.

WEST GERMANY'S SHORT-HAUL JET

THE West German Government has been advised by Lufthansa that, of 13 West German aircraft industry transport projects the airline was recently asked to study, two are worthy of government backing. One is the Hamburger Flugzeugbau HFB.314, a short-range jet; the other is the Heinkel He.211, a DC-3 replacement.

It is understood that the HFB.314 is an 80-seater, short-haul jet transport, presumably in the D.H.121/DC-9/Boeing 727 class, powered by two turbojets. The He.211 is said to be a 23-seater powered by two turboprops with STOL capabilities.

As already reported, the German Ministry of Economics is preparing a bill to finance the construction of new West German transports. It thus appears possible that, following the Lufthansa recommendation, these two designs may be proceeded with.

A significant point here is that West Germany's aircraft manufacturing plans do not, on the face of it, appear to be working towards rationalization of the Common Market aircraft industry.

FORTHCOMING EVENTS

Nov. 2. Brit.I.R.E. (Liverpool Branch): "Electronics in the Autopilot of Firestreak," by A. Bedford.
Nov. 3. R.Ae.S. Astronautics and Guided Flight Section: "Control Mechanisms," by Dr. F. Errington.
Nov. 3-6. Institute of Welding: Autumn Meeting.
Nov. 4. Air Britain: Photographic Contest, Caxton Hall, London, S.W.1.
Nov. 4-11. Kronfeld Club: Painting Competition.
Nov. 6. Helicopter Association: "Application of the Jet Flap to Rotor Control," by R. Dorand.
Nov. 7. D.H. Aeronautical Technical School Old Boys' Association: Annual Dinner.
Nov. 9. Institute of Transport: Lectures, including "Air Fare-structures," by J. L. Grumbridge.
Nov. 11. R.Ae.S. Graduates' and Students' Section: "Flight Testing of Rotorcraft," by S/L. W. R. Gellatly.
Nov. 13. R.Ae.S. Agricultural Aviation Group: Discussion on the Cranfield Conference.
Nov. 17. R.Ae.S.: "Magnetogasdynamics," by Dr. J. A. Shercliff.
Nov. 17-18. Institute of Aeronautical Sciences: National Turbine Powered Air Transportation Meeting, San Francisco.
Nov. 18. G.A.P.A.N.: Annual Service (St. Michaels, Cornhill) and a.g.m. (Innholder's Hall, College Street, London, E.C.4).
Nov. 19. R.Ae.S.: Fifteenth British Commonwealth Lecture, "Air Survey and Newly Developed Territories," by W. P. Smith.

R.Ae.S. Branch Fixtures (to Nov. 6): Nov. 2, *Boscombe Down*, "Inertial Navigation," by J. E. Pateman; *Henlow*, "Black Knight," by H. G. R. Robinson; *Derby*, Fourth Sir Henry Royce Memorial Lecture, "Power for an Airline," by B. S. Shenstone and H. G. Rossiter. Nov. 3, *Luton*, "Materials for Supersonic Aircraft," by G. Meikle. Nov. 4, *Bristol*, brains trust; *Swindon*, "Power from Nuclear Energy," by Dr. M. D. Wood. Nov. 6, *Brough*, annual dinner and dance.

B.O.A.C. 1958-59

Should the Corporation's Declared £5m Loss be £11½m?

Sir Gerard d'Erlanger

THE annual report and accounts for B.O.A.C. for the year ending March 31, 1959, published last week,* declares the total deficit of the Corporation and its associates as £5,179,420. This is the highest loss since 1949-50 (£7.8m).

Yet the balance sheet shows, in the item accumulated deficit, that the Corporation as at March 31, 1959 was about £11.6m worse off than at the same time in the previous year (the accumulated deficit is nearly £14.7m). How is the missing £6½m to be accounted for?

A preliminary *Flight* analysis of the report and accounts (a full assessment will be published in a later issue) suggests that B.O.A.C.'s real loss in 1958-59 was in fact more than double the declared loss. The "missing £6½m" can be accounted for as follows (round figures): —

(1) B.O.A.C. and Associates loss on operations	£5.2m	
(2) Development expenditure brought forward... ...	£5.0m	
(3) Loss on aircraft sales	£1.1m	£6.4m
(4) Other losses	£0.3m	
Total loss ...	£11.6m	

Items 2 and 3 above call for special comment. In the past few years, aircraft development expenditure has been carried forward by B.O.A.C. until such time as the aircraft concerned (Britannias and Comets) were in full operation. This of course is logical: and if the Corporation decides to lay the £5m against 1958-59 instead of spreading it over, say, the first five years of operation, this is entirely a matter for B.O.A.C. But it is inescapable that this cannot be written off in 1958-59 without being shown as a loss in that year's accounts.

Similarly, £1.1m has been lost on the disposal of aircraft and other assets. This can hardly be carried forward, since coming years might show an even higher loss on aircraft sales. Again, this is a loss that should reasonably be set against 1958-59.

Considering now the declared loss of £5.2m, it is apparent that though a profit of £843,123 was made on the parent Corporation's own operations, this was reduced to a loss of £2,084,651 after payment of interest on capital. This expenditure was the highest on record—£2,927,774, a full million more (as referred to later) than in the previous year. The remainder of the loss was from B.O.A.C. Associated Companies Ltd.: this was £2,532,207 on operations, plus £562,562 interest on capital.

The chairman, Sir Gerard d'Erlanger made the following comments on these losses: —

(1) Short fall of earnings due to the world trade recession during the second half of the year under review. Load factor dropped 3½ points to 57 per cent. The report could fairly have made the point that, had load factor been at the 60 per cent level of the previous year, another £3m would have been earned. The increase in capacity offered after pooling was not extravagant—14.5 per cent compared with the previous year.

(2) The "abnormal" net loss of £3.1m by the 14 associate companies was mostly accounted for by M.E.A. (£1.7m). The M.E.A. results are described as "exceptionally bad." In answer to a question, Sir Gerard in effect denied Sheikh Alamuddin's denial in September that B.O.A.C. have not lost money on M.E.A. Sir Gerard said "M.E.A.'s deficiencies have eroded into loan capital which is not supported by assets. We hope the loan will be repaid."

(3) The engineering strike of October 13-21, 1958, is estimated to have cost the Corporation "not less than £1.4m." It is apparent that this sum represents the net loss after allowance for reduced expenditures on fuel and oil, etc. Reference to Graph V in the report suggests that actual revenues lost were of the order of £1.8m, which makes the net loss estimate entirely reasonable, and a measure of the disruption that even an eight day strike can cause.

(4) The "considerable expenditure" on introducing new fleets into service was cited by Sir Gerard as an adverse factor. As discussed above, this expenditure is not included in the declared loss of £5,179,420. Instead, the following quite startling statement is made in the report: "We have seen fit to write-off a sum of £5m in respect of abnormal development costs of the Britannia and Comet aircraft."

This sum is presented in the profit and loss account as "amount written off in respect of development expenditure (on Britannia and Comet aircraft) incurred in circumstances beyond the control of the Corporation."

Despite all this, the Corporation's efficiency, measured in terms of cost per c.t.m. improved considerably during the year: specific cost fell from 38.7d to 36.2d, the biggest cut for eight years. It is odd that the report does not mention that nearly half of this cut was due to a saving in specific fuel costs of almost 20 per cent, due apparently to the Britannia's fuel economy.

The chairman emphasized that in considering the year's results, the Corporation has to pay interest on all its capital, unlike many of its competitors who only pay dividends out of profits. More than half the declared deficit of £5,179,420 is indeed due to remuneration of capital. The greatest increase in capital came in the form of advances from the Ministry—the long term debt which is a feature of so many other airline re-equipment programmes today. B.O.A.C.'s long term debt, in the form of these advances from the Ministry, shot up in the year under review to £65m from £41m in the previous year—an increase of nearly 60 per cent. It is not surprising that never before has B.O.A.C.'s remuneration of capital been so heavy or so high a proportion of earnings. It provides a measure of the heavy cost to B.O.A.C. of having to re-equip with American as well as British aircraft.

Sir Gerard and his deputy, Sir George Cribbett, and his managing director, Mr. Basil Smallpeice, were able to report optimistically at a news conference last week about the future. First, the managing director spoke of the present.

Mr. Smallpeice unveiled charts on the wall which showed the way things were going at that point in time, well over half-way through 1959-60. The profit-loss curve had shot up "into the black" over the past few months, having recently crossed the break-even line. It was estimated that, if the rest of the year went according to budget, the Corporation and its Associates, after remuneration of capital, might well break even in 1959-60. (Sir George Cribbett reported that the Associated Companies were likely to cut their losses from the £3.1m of the year under review to £0.5m next year.) So far there had been a "gratifying" net profit of £1½m in the first half of 1959-60.

The Future. Asked about the implications of the breakdown of the I.A.T.A. traffic conference at Honolulu [see leading article this week], Sir Gerard d'Erlanger echoed the words in his report to the effect that B.O.A.C. would continue to strive for orderly progress. He had not yet consulted with his Board on the matter, nor with his new Minister Mr. Sandys. But he replied in the affirmative to a questioner who asked whether he would now recommend to the Minister that B.O.A.C. should go ahead and implement economy-class fares on colonial cabotage routes. These routes would, he said, be those to East and Central Africa, to Hong Kong and Singapore, and also to the Caribbean (see map in *Flight* last week). Sir Gerard was asked whether B.O.A.C. was not provoking the chaos that it was allegedly striving to avoid? "I hope not," said Sir Gerard. "It will accelerate the adoption of lower fares."

Asked about the talks with Commonwealth carriers on the formation of the so-called Commonwealth Air Union, Mr. Smallpeice played down the possibility of equipment mergers: "I do not believe that Commonwealth carriers will take dictation on equipment . . . if the British industry produces the right aircraft they will buy them. That is fundamental." He thought that the arrangements now being discussed for a tripartite pool embracing B.O.A.C., Air-India and Qantas [on the routes between the U.K. and Australia] seemed to him to be a more effective idea than amalgamations. There would, he said, be further talks in India in November. He hoped also that the separate agreement being discussed between T.C.A. and B.O.A.C. would succeed.

Among other points made in the report or at question-time are the following: —

(1) B.O.A.C. estimate that the independent very low fare services, if granted would cost B.O.A.C. £5.5m due to diversion of traffic in the first full year of operation. Mr. Granville said that this calculation had been based on the frequencies applied for, and that it had assumed "some new traffic" generated by the independents. He did not know how much.

(2) B.O.A.C.'s 707s will be delivered in the latter part of December, the precise date not being certain, and a once-daily North Atlantic service (all in daylight eastbound) would start in April, followed by services to Toronto and Montreal in the summer, to San Francisco in the autumn and to Tokyo in the winter. In February 1961 the Polar route to Los Angeles would be inaugurated if, said Mr. Smallpeice, "we get the necessary bit of paper from the C.A.B." He did not anticipate that this would be a problem [the report "deeply deplores" the C.A.B.'s action in delaying the B.O.A.C. trans-Pacific service for six months].

**British Overseas Airways Corporation Annual Report and Accounts for the year ended March 31, 1959, H.M. Stationery Office, 4s 6d.*

Among those sheltering from the noonday sun during the Argosy's tropical trials at Khartoum are A.W.A. test pilots Bill Else (team captain, extreme right), Jim McCowan (behind), Joe Lancaster (with the pipe), with Tom Saunders (extreme left), who was in charge of flight testing

AIR COMMERCE . . .

JET RISKS

THE London insurance market will bear more than £¼ million of the insurance cover of the 707 which crashed on October 20. Legal owners of the aircraft at the time of the accident were Boeing. In addition to this sum will be re-insurance claims. This may bring to more than £6m the losses of the London and American aviation insurance markets on turbine aircraft accidents during 1959.

In view of the insurance industry's much criticized decision to raise its premium rates for the new aircraft, it is timely to report the recent annual meeting in Seville of the International Union of Aviation Insurers. The highlight of this conference was a review by Mr. Alan B. Hunter, of the United Kingdom, of jet-claims experience.

After the first year in which Comets, Boeing 707s, Caravelles and DC-8 aircraft had all seen airline service, said Mr. Hunter, claim costs had equalled in value 1.25 Comets, 1.25 Boeings and 0.33 DC-8s [the latter being on a maker's test flight].

With 18 Comets at risk throughout the world, so far only one had been destroyed. The circumstances of the accident had revealed, incidentally, that the fuselage had great strength. The Boeing losses had occurred with approximately 60 at risk amongst the airlines. Although many spectacular incidents had been reported in the press, only one aircraft of this type had been totally destroyed. By the end of 1960 some 350 jets should have been delivered and at the present rate of progress insurers must expect to pay for the equivalent of nine or ten total losses. This prediction was based on the assumption that the current generation of jet airliners would be destroyed at a rate no worse than that of well-tried aircraft such as the DC-6/7, Super Constellation and Viscount. There was apparently an inherent overall "wastage rate" which was applicable regardless of the aircraft or the operator.

Therefore, on hull insurance alone, the airlines of the world could not expect to see any reduction of current rates. When passenger liability insurance was added to the picture it became increasingly difficult to foresee a general reduction—largely owing to the trend towards high awards of damages in the American courts.

A study of helicopter risks revealed that transport operations (as typified by Sabena) were producing good results both in terms of hull claims and passenger claims. All other uses of helicopters were, however, proving very expensive to insurers by reason of the high cost of repairs, particularly as aerial-work helicopters were often used in inaccessible areas. Shaft-driven helicopters invariably suffered heavy damage in an accident and all these factors combined to aggravate the cost of claims; there seemed to be, added Mr. Hunter, no immediate prospect of any improvement.

Other topics discussed by the Union were of profound technical interest to aviation insurers: for example—the effects of the draft conventions on hire and charter of aircraft (I.C.A.O.); liability in nuclear operations (O.E.E.C. and I.A.E.A.); implications of the availability of large piston-engined aircraft; problems of broker's commission, no-claim bonus and "profit-sharing"; problems introduced by underwriting and the interests of aircraft financiers and the possibilities of airlines increasing the amounts of self-insurance.

The I.U.A.I. continues its functions as a means of exchanging information and ideas on an international basis. It is not, as has sometimes been suggested, an insurance rate-fixing or rate-recommending organization (unlike, for example, the traffic conferences of I.A.T.A. in relation to air fares).

Delegates attended the meeting from Belgium, Denmark, Egypt, Eire, Finland, France, Germany, United Kingdom, Netherlands, Italy, Norway, Portugal, Spain, Sweden, Switzerland, United States and Yugoslavia. The president elected for the forthcoming year is Mr. R. H. Jennens (United Kingdom). For the first time in the history of the Union, Lloyd's Aviation Underwriters' Association became a member.

BREVITIES

It is reported that REAL are likely to change their name to Aerovias Brasilia.

Aeroflot announce that fares on long-range domestic routes will be cut as from November 1 by amounts varying from 20 to 25 per cent.

The Ex-Im Bank is lending South African Airways £5.7m towards the purchase of three 707s, spare parts and equipment.

Construction of a new international airport at al-Ghouta, near Damascus, is under consideration by authorities in the Syrian region of the U.A.R. A West German company is to make a study of the project.

The Guild of Air Traffic Control Officers announce the inauguration of a Wessex Lodge, the seventh such division of the Guild. Other Lodges, for Scotland and Singapore, are being considered.

The retirement is announced of Mr. A. C. ("Wickham") Hughes, B.O.A.C.'s agency and inter-line manager for seven years. His connections with B.O.A.C. go back to 1934 when he joined Imperial Airways. Mr. Hughes, who is 63, is succeeded by Mr. Kenneth Everall.

Iberia will pay a $100,00 deposit on each of the three DC-8s recently ordered from Douglas, with the balance of 5 per cent of total purchase price due by the end of 1959. A further 15 per cent of the cost ($4,787,400 per aircraft) will be paid in 1960. The remaining 80 per cent will be financed by the Ex-Im Bank, a quarter of this being financed by Douglas.

A series of five lectures on advertising and public relations will take place in London at the Royal Festival Hall, Recital Room, at 6.15 pm on each Tuesday evening from November 3 to December 1 inclusive. The theme is "Freedom Of Choice Through Advertising". Enquiries should be addressed to the Junior Chamber of Commerce for London, 69, Cannon Street, E.C.4, telephone Covent Garden 2191.

B.O.A.C. has applied for the return of premises and property sequestrated in Egypt in 1956.

It is reported that the Rumanian airline TAROM is likely to acquire four Il-18s for delivery next year. The airline at present operates Il-14s and Li-2s.

A.L.P.A. have advocated that F.A.A. proposals to make airborne radar mandatory in four-engine transports should be extended to cargo aircraft and the fleets of local-service airlines.

Lufthansa have been recording high Viscount 814 load factors on their routes to London—about 80 per cent both ways Munich - Frankfurt - London, and 70 per cent on the route Hamburg - Dusseldorf - London (75 per cent in the return direction).

"Pilot error" has been given as one probable cause of the accident to the Lufthansa Super Constellation which crashed at Rio de Janeiro on January 11. The report was prepared by Brazilian officials aided by West German investigators. The report added that the exact cause could not be ascertained.

There are now more than 280 helicopter operators in the United States and Canada. This fact was given in a paper read at a heliport design conference in Los Angeles last month sponsored by the L.A. Chamber of Commerce. The paper, *Heliports—A Key to Urban Air Transport*, was by Harvey Gaylord, president of Bell Helicopters.

Fairchild have appointed Dallas Airmotive of Texas and Piedmont Aviation of Winston-Salem, N.C., as sales representatives and service dealers for the F-27. As sales representatives these two companies will represent Fairchild in the territory in which Fairchild possesses F-27 sales rights, namely the Western Hemisphere excluding Brazil. They may make contact with potential customers except governments, government-owned airlines and public air carriers. The companies will also provide facilities for the repair, overhaul, modification and servicing of the F-27.

Mr. J. L. Roberts has been appointed British Civil Air Attaché, Bonn, in succession to Mr. J. Bonfield.

Los Angeles Airways have ordered five Sikorsky S-61s (at about £230,000 each) for service from 1960 and 1961.

Ghana Airways' first annual report shows a loss of £174,000 in the first year of operation—rather less than predicted.

It is reported that Slick Airways, whose option on six Lockheed GL-207 freighters is now in doubt, are seriously considering the purchase of Canadair CL-44s.

All Australian domestic air fares were increased by 10 per cent (tourist) and 3½ per cent (first class) on October 16. A charge is now also to be made for ground transport between airport and town terminal.

K.L.M. is to introduce DC-8s on its Amsterdam - Montreal - Houston - Mexico service in May next year, on the Tokyo service in the summer of 1960 and on the Sydney route in October. Electras will enter service, on the Cairo and Damascus routes, this December.

De Havilland Aircraft is negotiating a possible order for Comet 4Bs with Lufthansa. The aircraft—the first 4B to visit Germany—was demonstrated to air force and government officials at Wahn airport on October 16.

Speaking on Moscow Radio on October 14, Mr. A. H. Milward, chief executive of B.E.A., said that "One of the most interesting things to find since we started our route is that the freight business is much greater than we expected . . . I think the business will continue to expand."

Prices shown for DC-7Cs, DC-4Ms, DC-6s and 6Bs and DC-3s in the fortieth issue of *Market Report* have dropped substantially since the last issue was published—in the case of DC-7Cs by one-third to £357,000 ($1m).

Lufthansa's net loss for the 1958 financial year was £2,702,338, compared with £2,093,220 in the previous year, although the number of passengers carried increased by 44.8 per cent, freight by 68.5 per cent and mail by 36.5 per cent.

T.C.A.'s DC-8 programme, following delivery of the first aircraft in December, calls for inauguration of transcontinental jet services on April 1 between Vancouver and Montreal/Toronto; and inauguration of services between Canada and the U.K. on June 1. Seating will be for 127 passengers, 28 first-class and 99 economy-class.

Convair have sold the last of 25 CV-440s built but not sold when the production line closed early in 1959. They have reportedly built 1,075 Convair-liners since 1947. The last 25 were taken by the executive market and by Mohawk Airlines (five), General Motors (six), the Greek Government (two).

The $45 ("all-time low") economy-class fares offered by National and Northeast between New York and Miami may be discontinued, at the request of the two airlines. The fares were introduced in August. No explanation has been offered, and Eastern Air Lines, who also offer the fare, have not joined National and Northeast in requesting discontinuation of the fare.

President Frondizi of Argentina has asked for and received the resignation of Señor Juan Jose Guiraldes, president of Aerolineas Argentinas. It is said that Señor Guiraldes has been criticized by the Government's new Finance Minister, Señor Alvaro Alsogaray (who was appointed last August). It is understood that the airline's order for six Comets, three of which are still to be delivered, remains firm.

In December S.A.A. are to introduce a weekly DC-3 service between Johannesburg and Durban for non-Europeans. Fares will be the same as for S.A.A. coach services, 25 per cent less than Viscount fares. Non-white stewards are being trained for the service. Another company, Protea Airlines, is awaiting permission from the National Transport Commission in Pretoria to operate non-European services at even lower fares with Vikings. S.A.A.'s new service may, however, prejudice this application.

Mr. Henry K. Noun, pictured here, is replacing Mr. Fuad Sidrassi as head of M.E.A.'s office in London

It is reported that Braniff Airways are likely to convert four of their Convair 440s to Allison 501-D13 turboprops.

Delivery date of Alitalia's first Caravelle will be May 1960, followed by the second in June and the third in July. An option has been taken by the airline on four more Caravelles for delivery in the spring of 1960.

June 1961 has been set by B.E.A. for the introduction of scheduled helicopter services from Penzance to St. Mary's Airport, Scilly Isles, and later to a site nearer Hugh Town, the capital. At least six months will be devoted to studying costs on this route, which will be served by Vertol 107, Sikorsky S-61 or Bristol 192 helicopters. A decision has yet to be taken on the actual choice of helicopter. Also under discussion is an arrangement between B.E.A., Air France and Sabena by which inter-city helicopter services might be operated in pool in about 1962.

MID-CONTINENT INTERNATIONAL (continued from page 476)

Finally, I talked about T.W.A.'s equipment plans with Russ Rourke, who is in charge of equipment planning and development at the airline's office at Kansas City airport. T.W.A.'s immediate jet plans are to build up a fleet of fifteen Boeing 707-131s, thirteen 707-331s and thirty Convair 880s. Most of the domestic Boeings have now been delivered and the first Intercontinental 707-331 arrived at Kansas City during the past week; it will be the first T.W.A. jet to be used on overseas services and the inaugural service to London will take place on November 23.

The Convair 880—the first of which is to be delivered next month—will reinforce the Boeings on domestic services, particularly on the shorter stages which it will progressively take over from the Constellation 749s and, eventually, the Super Gs as well.

One of the airline's more intractable problems is finding the best equipment to use on the extension of its European routes through Bombay and Bangkok to Manila; the quantity of through traffic generated on these sectors is small, and load factors are not very high—certainly they are barely sufficient to make possible economical operation with the long range 707-331s. The Convair 880 would probably fit into these routes quite well, but its use implies a change of gauge 4,500 miles or so away from the overhaul base—for the 880s are unsuitable for a transatlantic operation. The greatest hope, as the airline sees it, is that a spread of economy fares to the Eastern routes will generate the additional traffic they need in order to be able to use the Intercontinentals on a leap-frog of alternative traffic stops. (This might be one of the reasons behind T.W.A.'s firm support of economy-class extensions in IATA at Tokyo this year.)

The airline is also faced with some interesting equipment alternatives. It was argued a few months ago that it would make good sense to interchange with PanAm six Intercontinental -331s for six additional domestic 707s. In fact, only the half of this arrangement which concerns disposal to PanAm of the -331s has been carried through, and T.W.A. are not now going to take additional -121s. They have, on the other hand, looked very carefully at the Convair 600 as a possible supplement to their 880 fleet and as a means of overcoming change of gauge difficulties on their Eastern routes, but no decision has yet been taken and I gathered that, on balance, the airline preferred to wait and see how its Boeing 707 and Convair 880 operations are going to work out.

A useful alternative to additional -120s might also be the turbofan-powered Boeing 720B (which includes an extended wing leading-edge and an increase in minimum-cost cruise from Mach 0.82 to 0.84). The logic of the purchase might depend on re-equipping, at some later stage, with turbofans for the 707-121s, and it is not impossible to imagine (say T.W.A.) a situation where the mainstays of the airline's fleet are turbofan-powered 707-120s and 720s and Convair 880s and 600s; two basic types of aircraft could then cover a wide segment of the range spectrum.

Looking further ahead, T.W.A. are convinced that by 1963 they will need a short range jet, and they are now studying the various designs on offer. On Russ Rourke's desk was a model of the Caravelle, and I asked him if there was any prejudice within T.W.A. to "buying foreign." No, he said, there was not; T.W.A. had in fact bought some of its Constellation galley equipment from England (from G.E.C.), had considered the purchase of Britannias, and had been close to deciding on Conway engines for its 707-331s. Like everyone else in T.W.A. Mr. Rourke commented most favourably on Rolls-Royce's business methods and their technical service and, "we might well have clinched the order if it hadn't been for our now apparently unfounded doubts whether Rolls development would keep pace with their promises and whether one or two technical features—such as aluminium first-stage compressor blades—would prove satisfactory."

Which short-range jets were T.W.A. considering? It was T.W.A.'s policy, said Mr. Rourke, to consider what would be most suitable for their requirements rather than to demand aircraft that were specially tailored for them, although in some instances—for example, on the fuselage diameter of the Boeings—they had had a say in the form the design should take. They were thus considering everything that was on offer. Had T.W.A. recently been approached by Airco with the D.H.121? "No," was the answer, "we haven't heard a great deal from British manufacturers recently."

Finally we talked of the era of the supersonic transport. Supersonic airliners, said Russ Rourke, should be possible by 1972, and he anticipated that—"operating in the Mach 3 area"—seat-mile costs of the same level as those pertaining now should just be feasible; T.W.A. were keenly interested and certainly intended to operate supersonically when the economics looked right. But judgment of the best equipment from an airline point of view would become increasingly difficult. Already computer techniques were being used to determine the optimum aircraft for a particular series of tasks. They were very valuable, and more would come.

An aerial view of the new Air Ministry build ing on Whitehall (left-hand half of the block which is shared with the Board of Trade) taken from a Sycamore of the C.F.S., South Cerney by S/L. J. R. Dowling, who was first C.O. of the helicopter training school there

SERVICE AVIATION

Royal Air Forces and Naval Flying News

Rongatai Incident

A VULCAN of No. 617 Sqn. had to make an emergency landing at Ohakea R.N.Z.A.F. station last Sunday after damaging its port undercarriage and wing in making an approach at Wellington's new international airport. Captained by S/L. A. A. Smailes, the Vulcan had flown from Ohakea to Rongatai Airport to take part in an opening display by visiting aircraft. None of the crew of four was injured in the landing at Ohakea, which was made on a foam-covered runway.

Cranwell's Academic Future

BRIEF reference was made in a news-item last week (p. 421) to the academic changes at Cranwell from September 1961. These not only affect entry to the college—G.C.E. standards replacing the examination set by the Civil Service Commissioners—but introduce a broadening of the syllabus. This means there will be more opportunity of developing individual leanings: cadets showing a particular aptitude for science subjects will concentrate mainly on them but be given a sound grounding in the humanities; those with humanities uppermost in their affections will be given a deeper course of military studies.

". . . to fight another day"

WITHIN an hour of ejecting from his Sea Hawk over the South China Sea recently a Fleet Air Arm pilot, Sub-Lt. J. G. Wood, was safe and dry aboard U.S.S. *Lexington*. He had ejected following a collision between his own aircraft and another Sea Hawk of No. 801 Sqn. When Sub-Lt. Wood left his machine, having found it uncontrollable, his parachute was seen by Skyraiders of *Lexington* and rescue operations were initiated. The other Sea Hawk, though damaged, was able to return to H.M.S. *Centaur;* and Sub-Lt. Wood was picked up by a U.S.N. helicopter—piloted by a Lt. Wood—using a new type of rescue apparatus described as "greatly resembling a three-fluke anchor." Before being transferred by line from *Lexington* to H.M.S. *Caprice* for return to *Centaur*, after suitable refreshment and a medical check-up (he had only minor bruises and abrasions), Sub-Lt. Wood was presented with various mementoes of his unscheduled visit to the U.S. Navy—including a bright orange flight suit, "so we can see you better next time."

Last of the Mustangs

MUSTANG fighters have been withdrawn from service by the R.A.A.F. after employment since 1944, when the first Australian unit to fly them was No. 3 Sqn. in Northern Italy. They were operated for nine months in the Korean War by No. 77 Sqn., and the last R.A.A.F. unit so equipped was No. 24 (City of Adelaide) Sqn. of the Citizen Air Force.

The first Mustang, designated XP-51 and designed to British specifications, was built in the U.S.A. by North American Inc. and the prototype flew in October 1940. When production ended in 1946 a total of 15,576 had been built. The first Australian-built Mustang was test-flown at the end of April 1945 and between then and July 1951 the Commonwealth Aircraft Corporation produced 200 of these versatile machines.

IN BRIEF

Marshal of the R.A.F. Sir John Salmon visited the headquarters of the R.A.F. Benevolent Fund last Friday (October 23) to wish well on its 40th anniversary. He has been vice-president since its foundation in 1919.

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R.A.F. Leuchars has won the first annual Fighter Command photographic competition. Stradishall came second and Duxford third, placings based on the success of individual competitors.

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The Winter 1959/60 issue of *The Royal Air Force Athletic and Games Handbook* has recently been published. Copies (price 4s) are available from the R.A.F. Sports Board, Air Ministry, W.C.1.

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Leeds U.A.S. is being transferred to R.A.F. Church Fenton, following the Air Ministry decision to close R.A.F. Yeadon, and will re-start operations on November 2. No decision has yet been made about the future of No. 3609 (West Riding) F.C.U., R.Aux.A.F., also based at Yeadon.

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The R.A.F., Princess Mary's R.A.F. Nursing Service, W.R.A.F. and the Royal Observer Corps will be represented during next week-end (November 7 to 8) at the Festival of Remembrance in the Royal Albert Hall and at remembrance services at the Cenotaph and in Westminster Abbey.

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Aberdeen University Air Squadron is holding its annual dinner at the Royal Athenaeum Restaurant, Aberdeen, on Saturday, November 28. Past and present officers and members who are interested in attending should write to the Secretary, Aberdeen U.A.S., Bedford Road, Aberdeen, as soon as possible.

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G/C. M. M. Gardham of Technical Training Command headquarters won this year's Gordon Shephard Memorial Prize essay competition. Second prize went to A. Cdre. D. N. Kington-Blair-Oliphant of Air Ministry, third to S/L. G. C. T. Richards of Flying Training Command headquarters and fourth to G/C. W. Carter of the Joint Services Staff College.

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Officers and ratings making up the first part of the ship's company of *Hermes* joined her last Friday at the Barrow-in-Furness yard of Vickers-Armstrongs Ltd. to man the new carrier during trials. Launched in February 1953, she is to commission for service with the Royal Navy at Portsmouth on November 2 under the command of Capt. D. S. Tibbits.

G/C. J. E. (Johnny) Johnson, the distinguished Battle of Britain pilot who now commands R.A.F. Cottesmore, seen on his recent visit to Canada in conversation with the Hon. J. A. D. McCurdy, who fifty years ago became the first British subject to make a sustained, controlled flight within the British Empire

Mr. James Martin, director of the Martin-Baker Aircraft Co. Ltd., presenting F/O. P. Baigent (left) and F/L. H. Starke of No. 23 Sqn. with ties of a newly formed club for aircrew who have ejected using Martin-Baker equipment. The ties bear the red triangle warning-sign carried on aircraft so fitted. About 300 aircrew are eligible and application forms can be obtained from the company at Higher Denham, near Uxbridge, Middx

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